



US006825943B1

(12) **United States Patent**  
**Barry et al.**

(10) **Patent No.:** **US 6,825,943 B1**  
(45) **Date of Patent:** **Nov. 30, 2004**

(54) **METHOD AND APPARATUS TO PERMIT EFFICIENT MULTIPLE PARALLEL IMAGE PROCESSING OF LARGE JOBS**

5,179,637 A	1/1993	Nardozzi	395/114
5,287,194 A	2/1994	Lobiondo	358/296
5,333,246 A	7/1994	Nagasaka	395/133
5,550,957 A *	8/1996	Davidson et al.	358/1.15
5,596,416 A *	1/1997	Barry et al.	358/296
5,859,711 A	1/1999	Barry et al.	358/296

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\* cited by examiner

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(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(57) **ABSTRACT**

(21) Appl. No.: **09/438,228**

The present invention disclosed and claimed herein comprises a system and method for parallel conversion processing of a print job in a print system having a plurality of RIP engines, comprising the steps of: defining the print job for RIP of select portions of the print job in parallel; partitioning the print job into select portions according to defined boundaries; generating a substitute RIP instruction for each select portion of the print job; and processing the RIP requirements of each select portion in an assigned one of the plurality of RIP engines according to the substitute RIP instruction.

(22) Filed: **Nov. 12, 1999**

(51) **Int. Cl.**<sup>7</sup> ..... **G06K 15/00**

(52) **U.S. Cl.** ..... **358/1.15; 385/1.1**

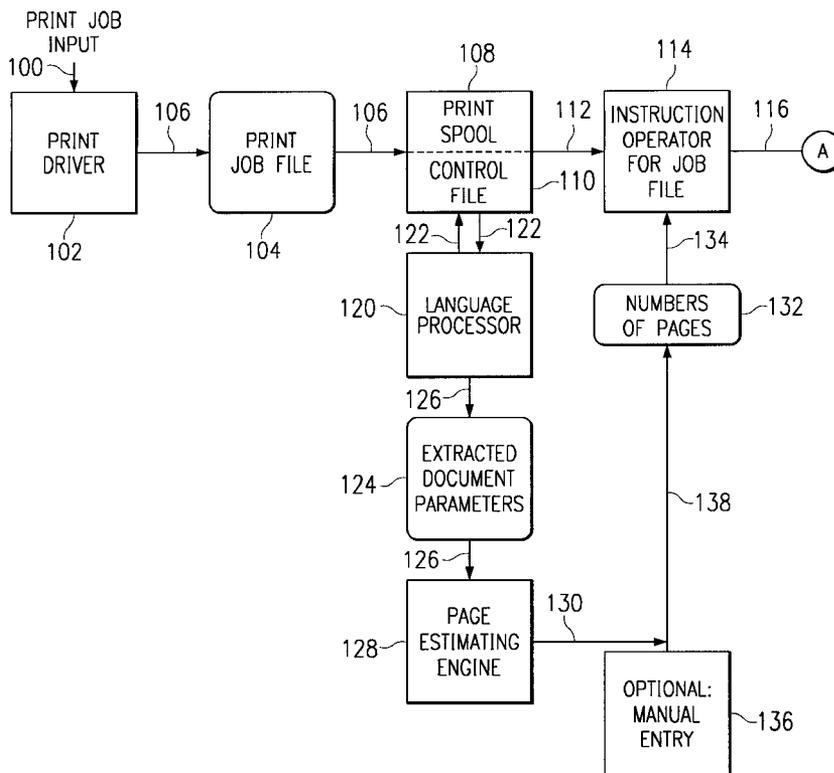
(58) **Field of Search** ..... 358/1.1, 1.6, 1.13, 358/1.15, 1.16, 1.17, 1.18, 403, 444, 445, 450, 453; 345/530, 545, 546, 502, 520, 505, 506, 522

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

5,113,494 A 5/1992 Menendez et al. .... 395/163

**36 Claims, 10 Drawing Sheets**



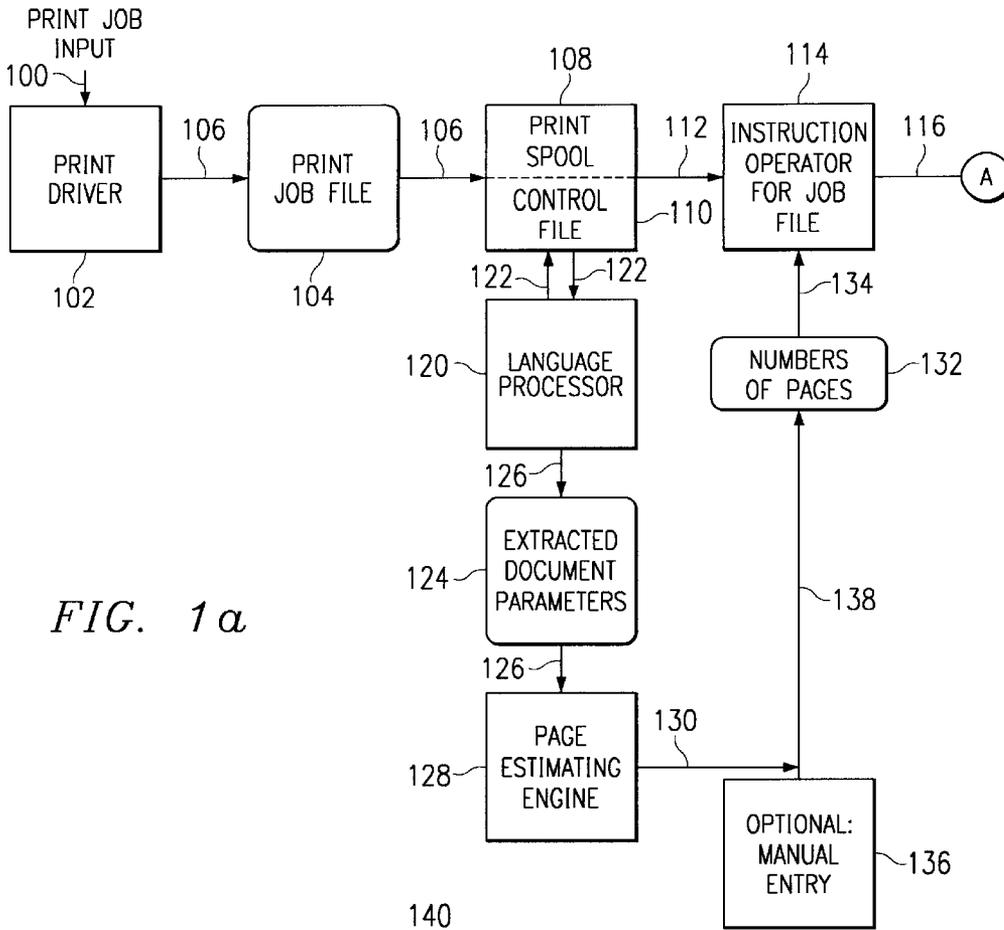


FIG. 1a

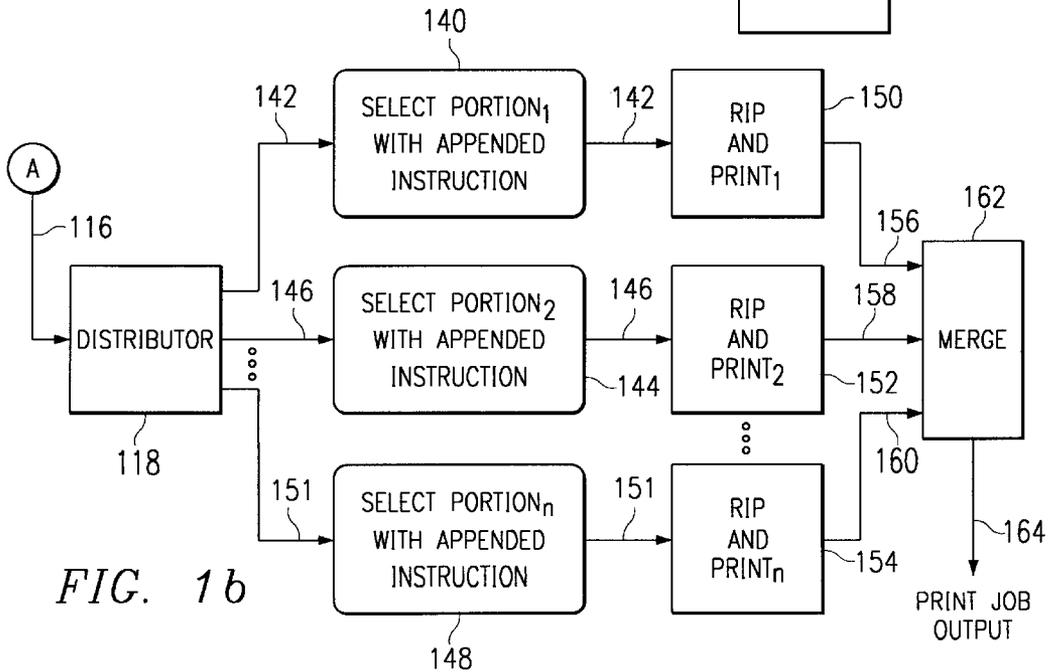


FIG. 1b

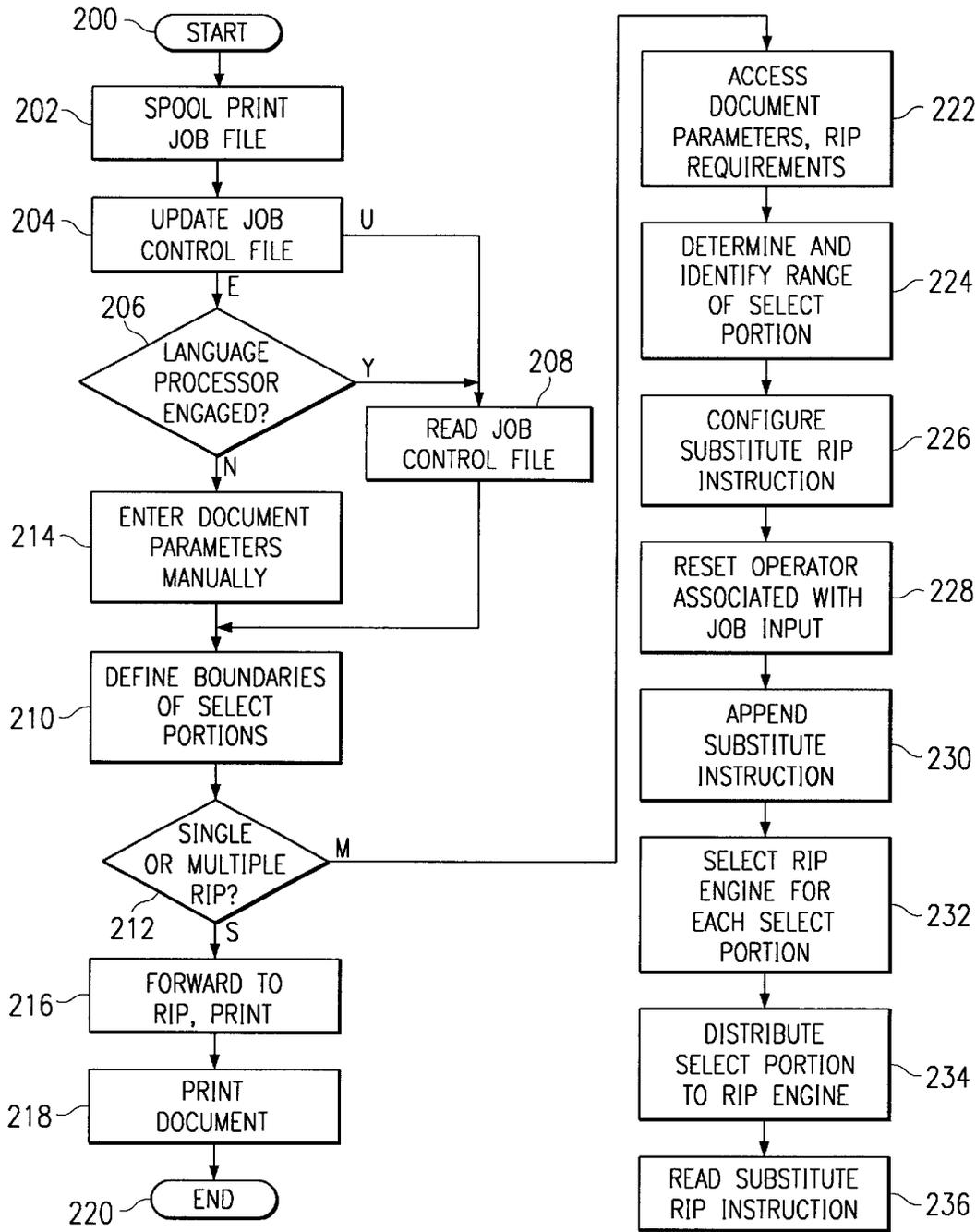
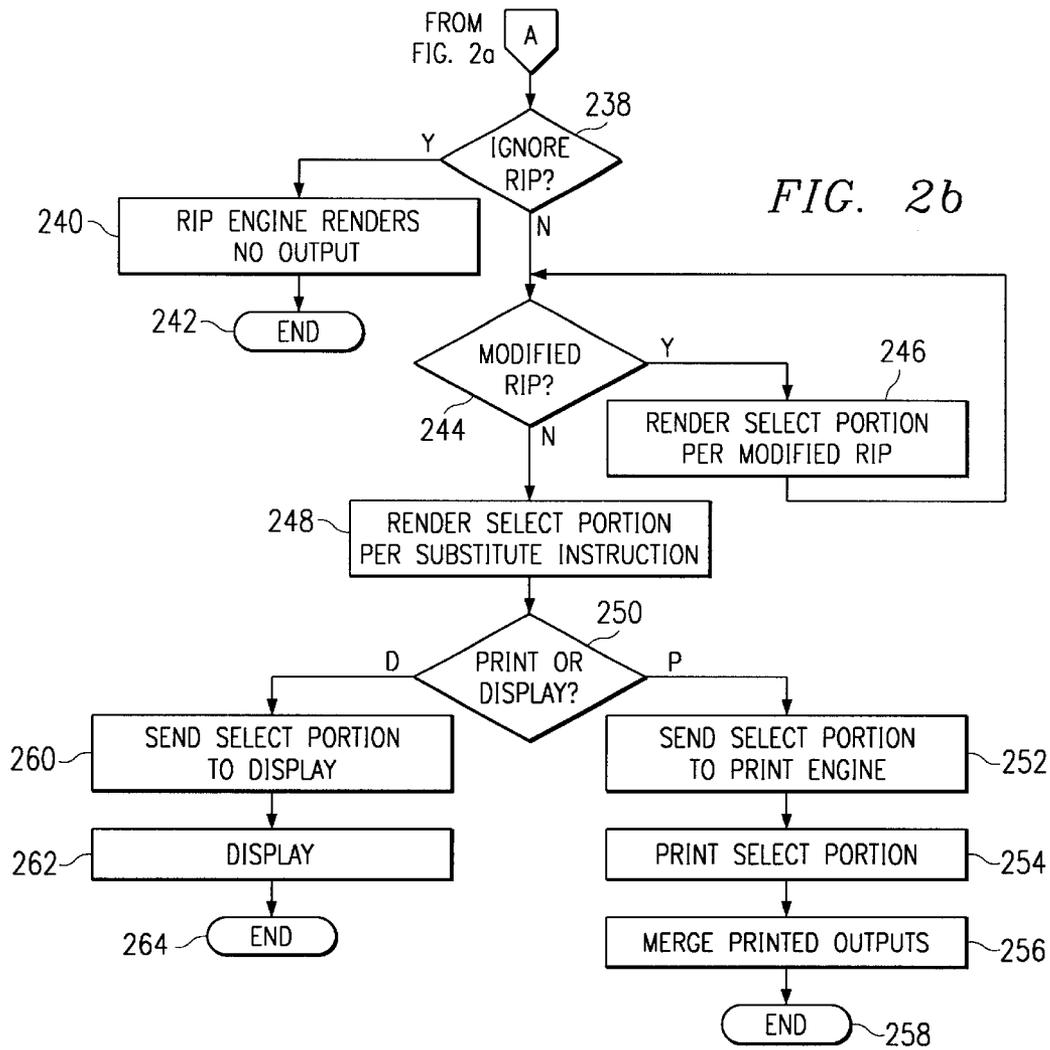
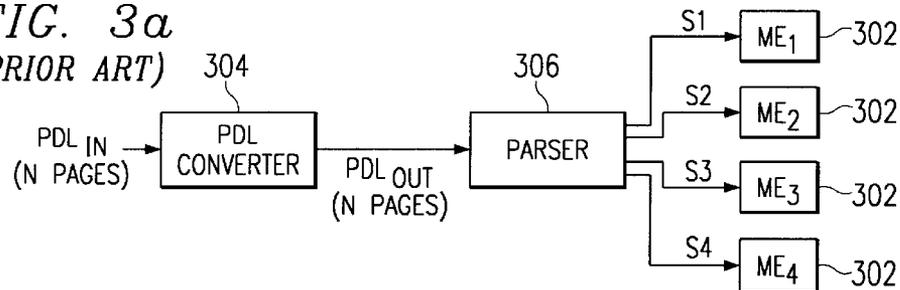


FIG. 2a

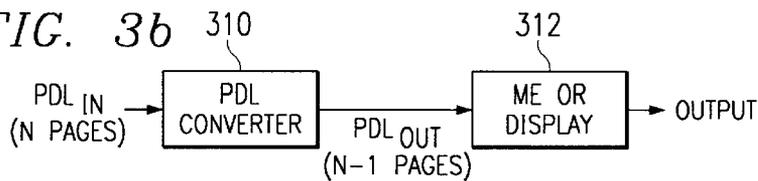
TO FIG. 2b



*FIG. 3a*  
(PRIOR ART)



*FIG. 3b*



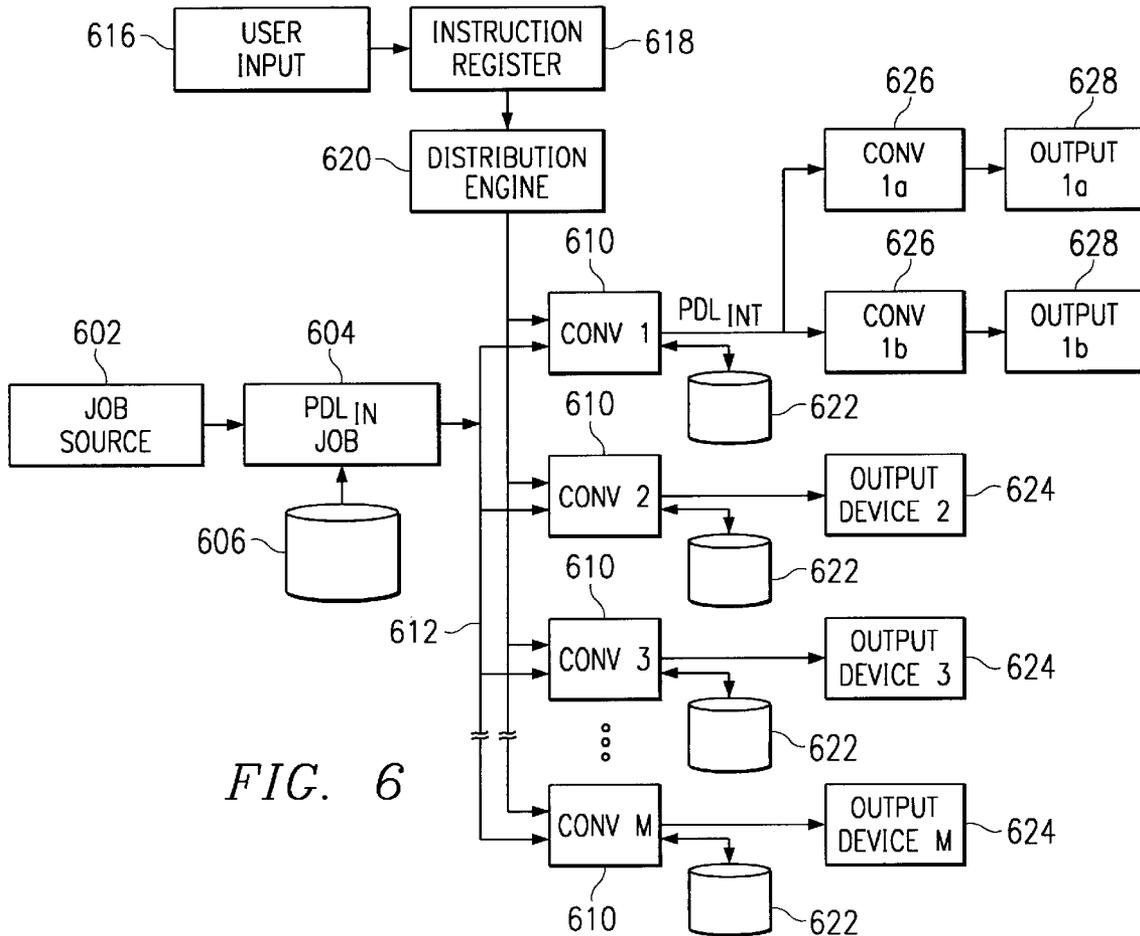
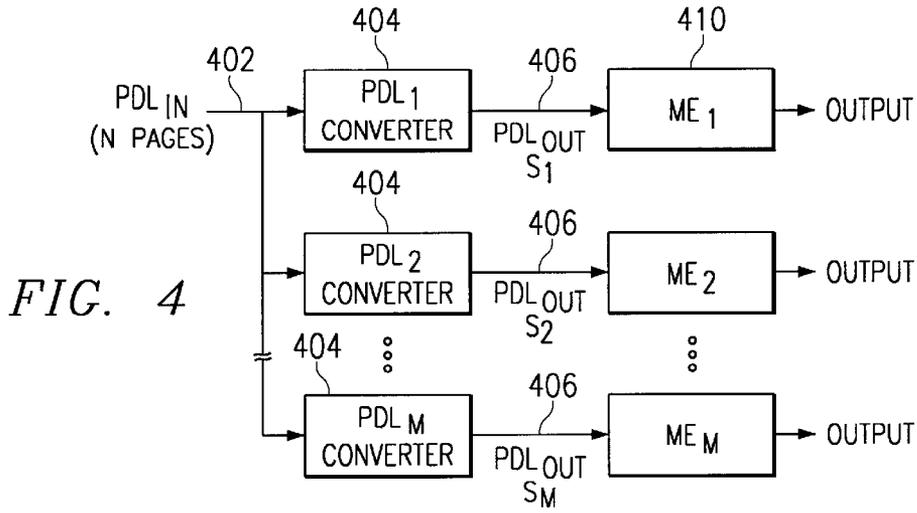


FIG. 5a  
(PRIOR ART)

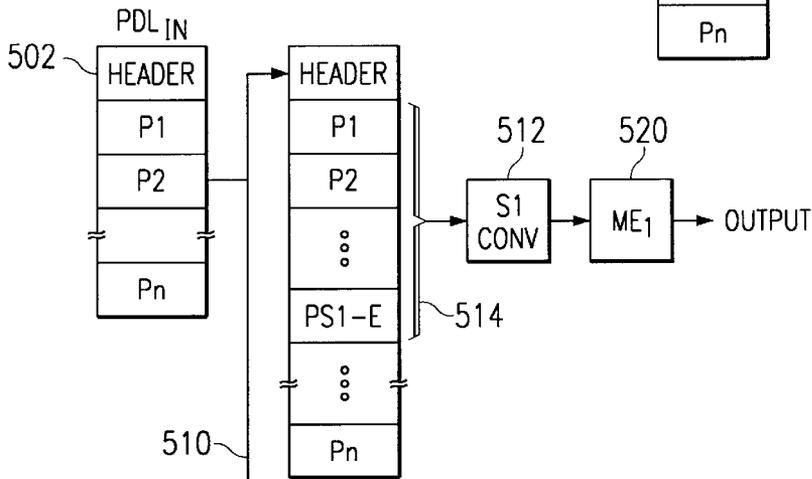
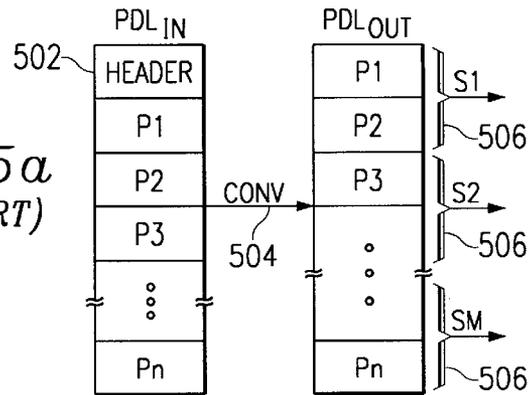
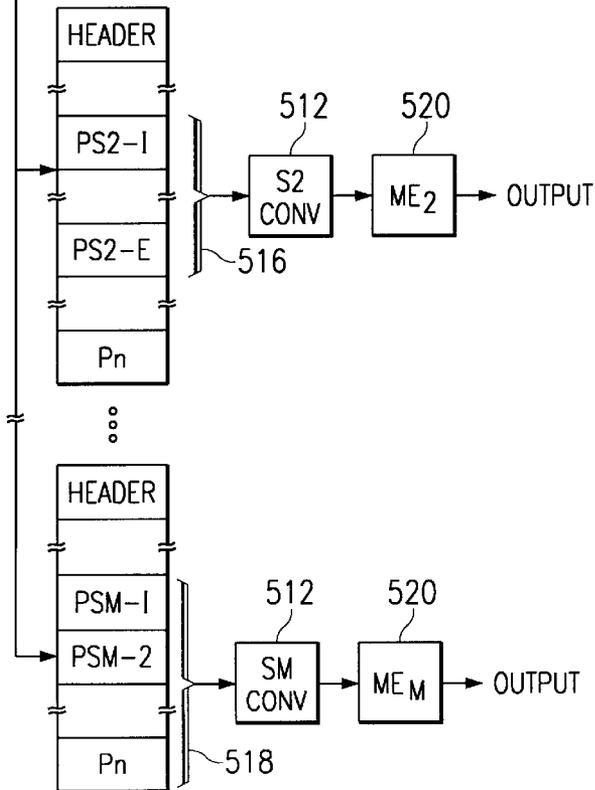


FIG. 5b



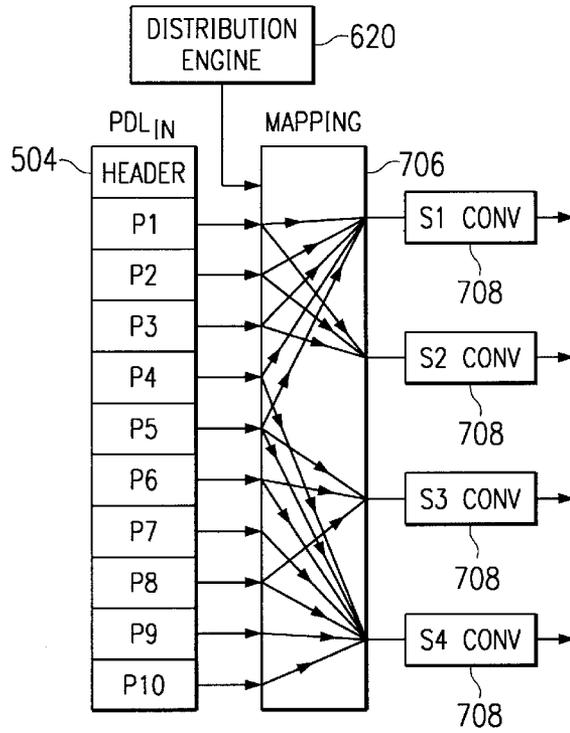


FIG. 7

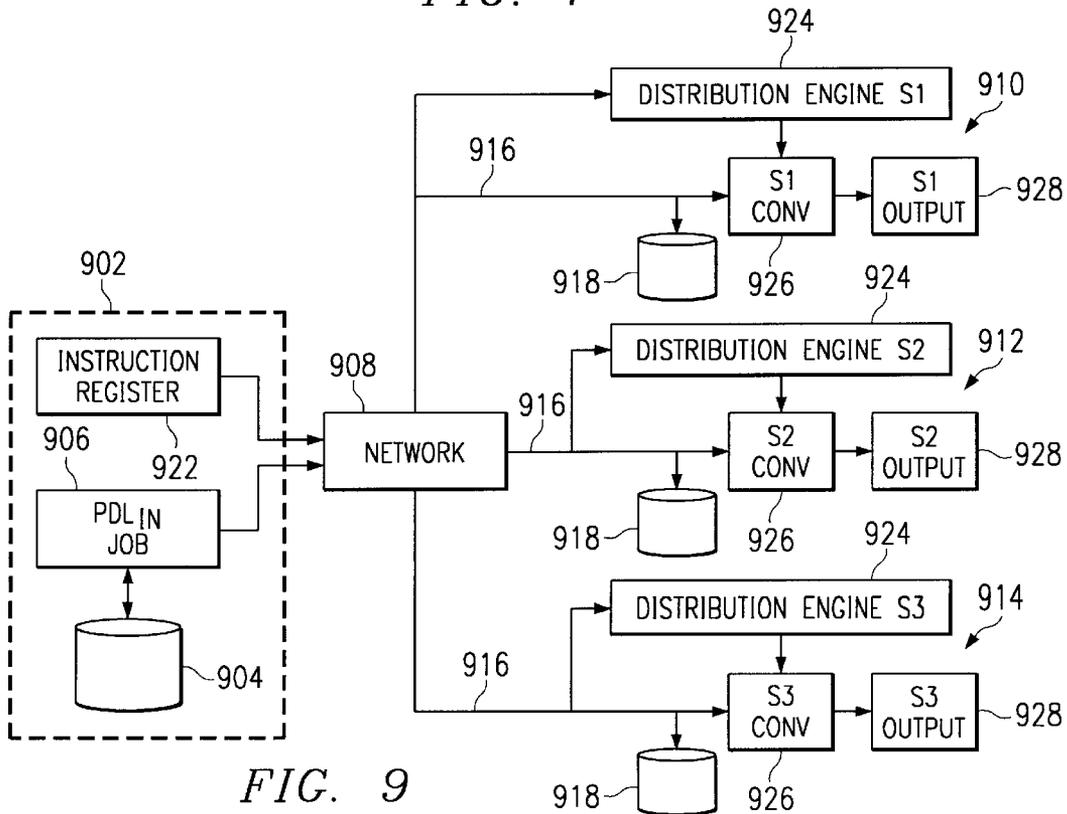


FIG. 9

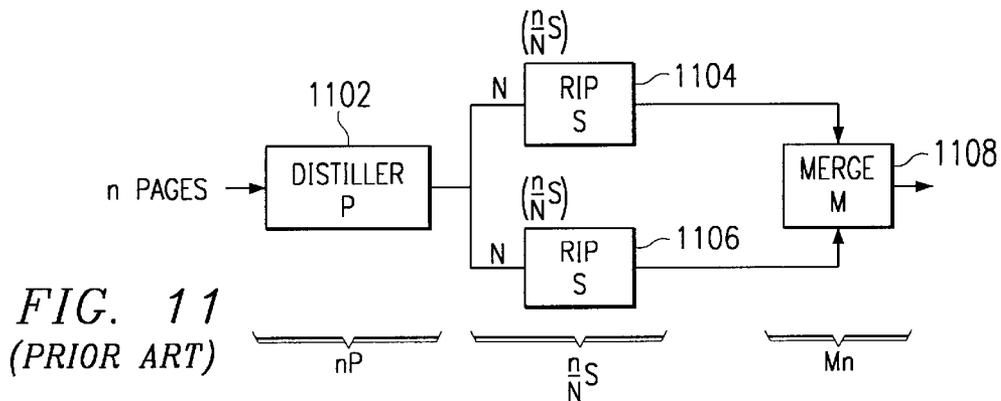
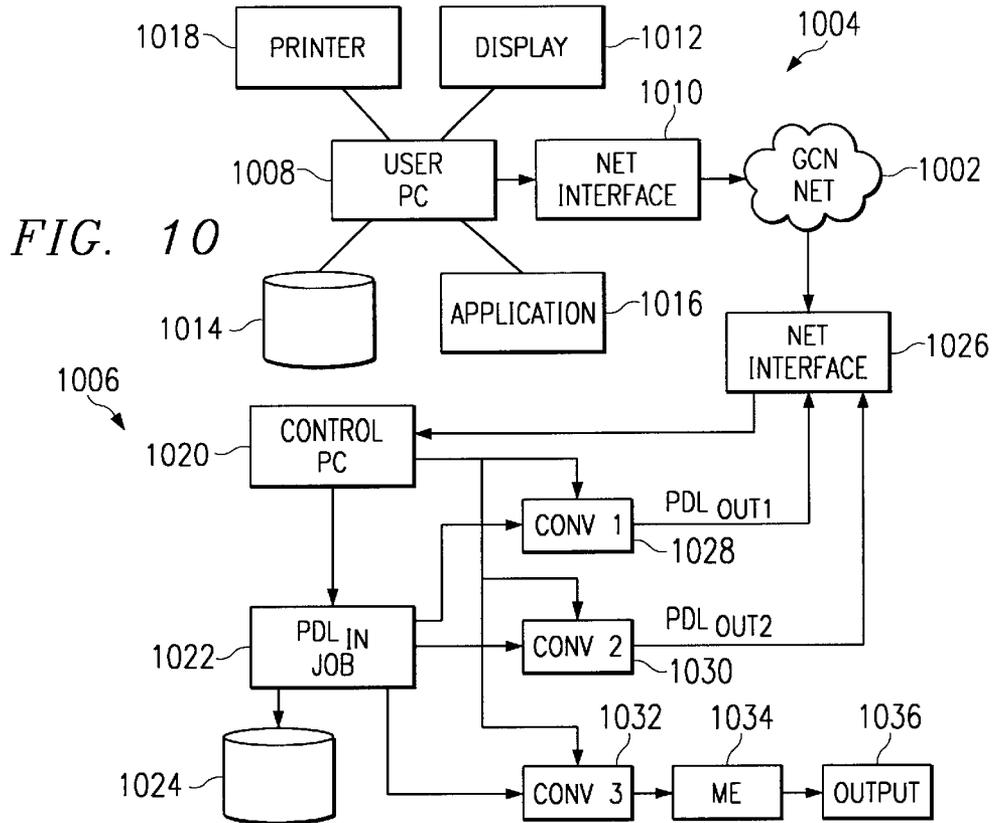
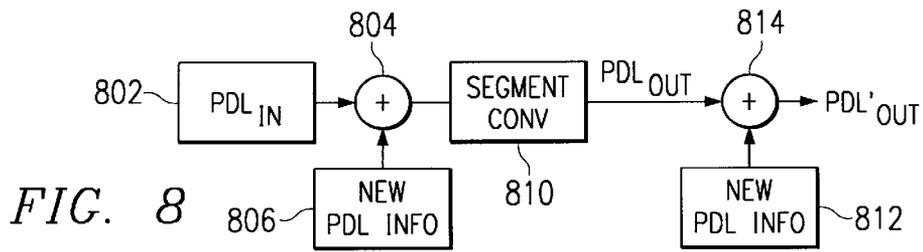


FIG. 12

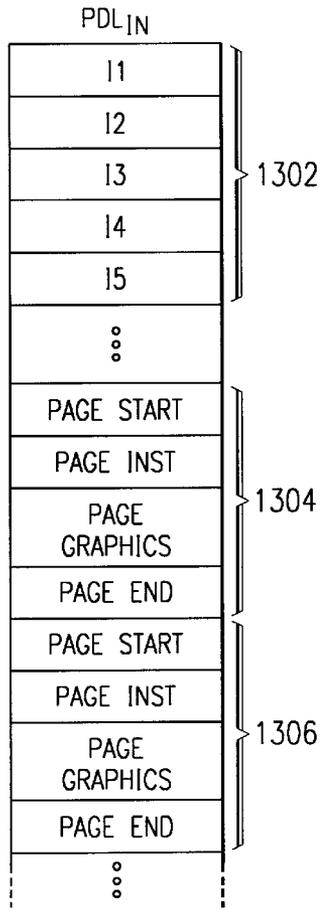
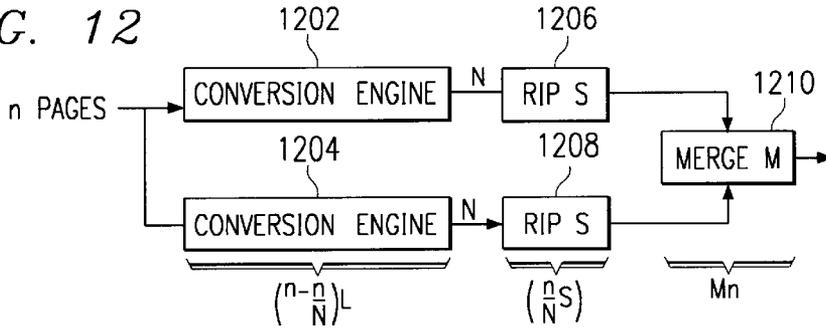


FIG. 13

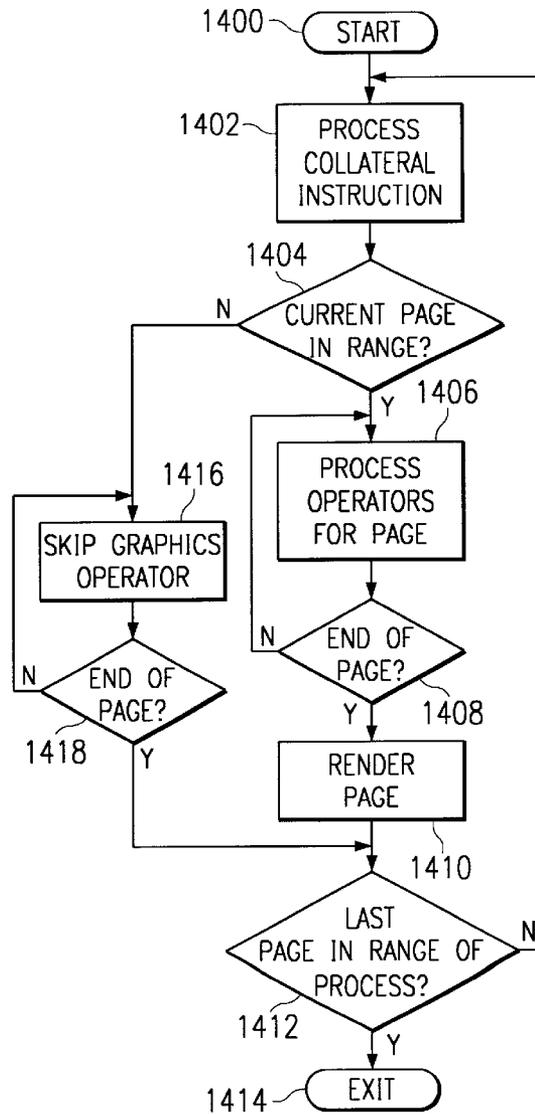


FIG. 14

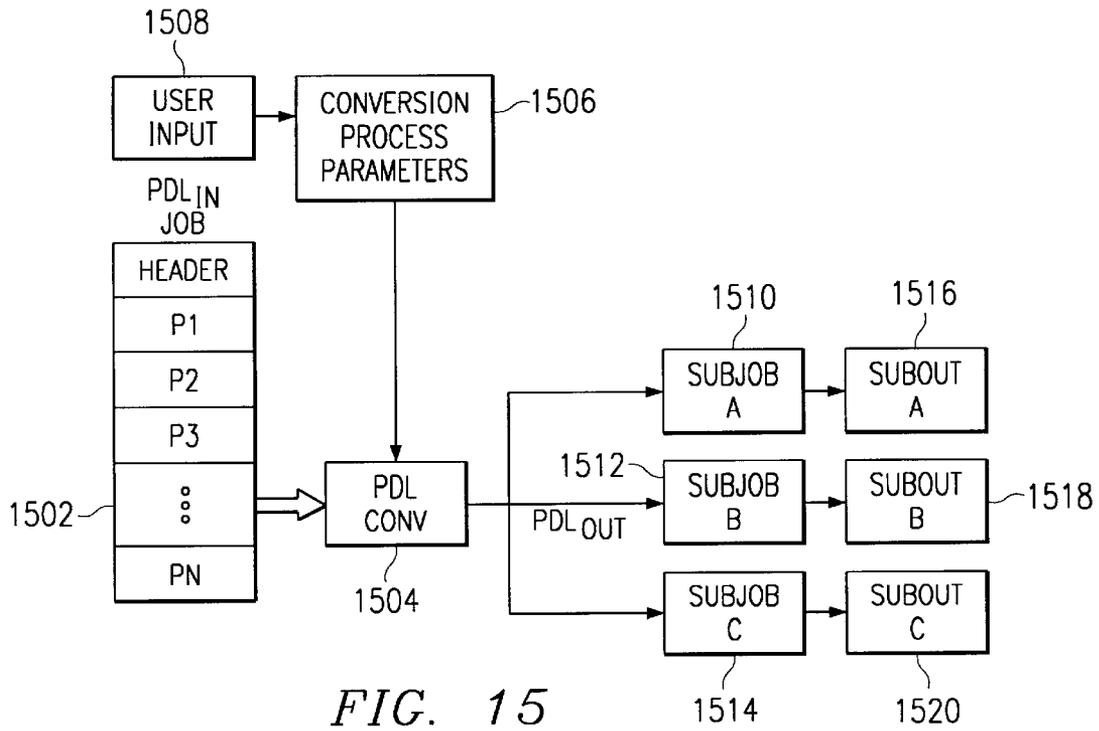


FIG. 15

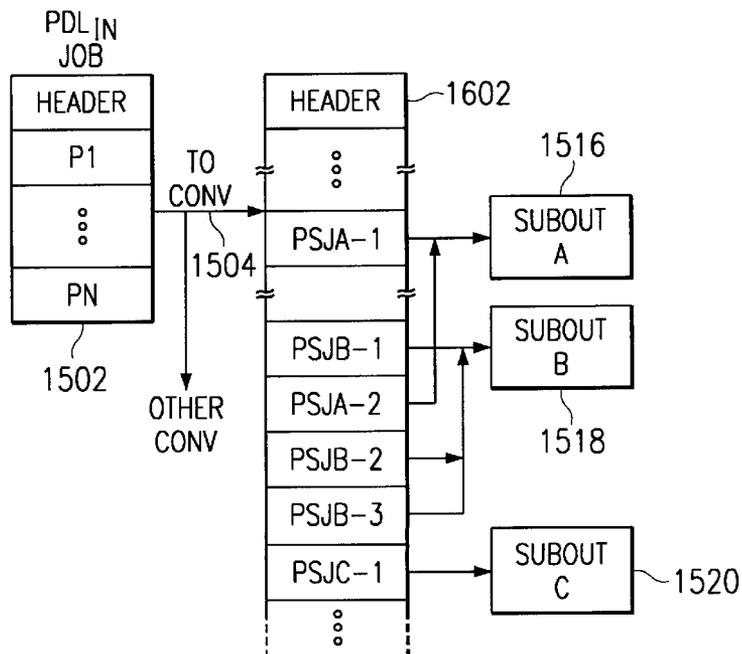


FIG. 16

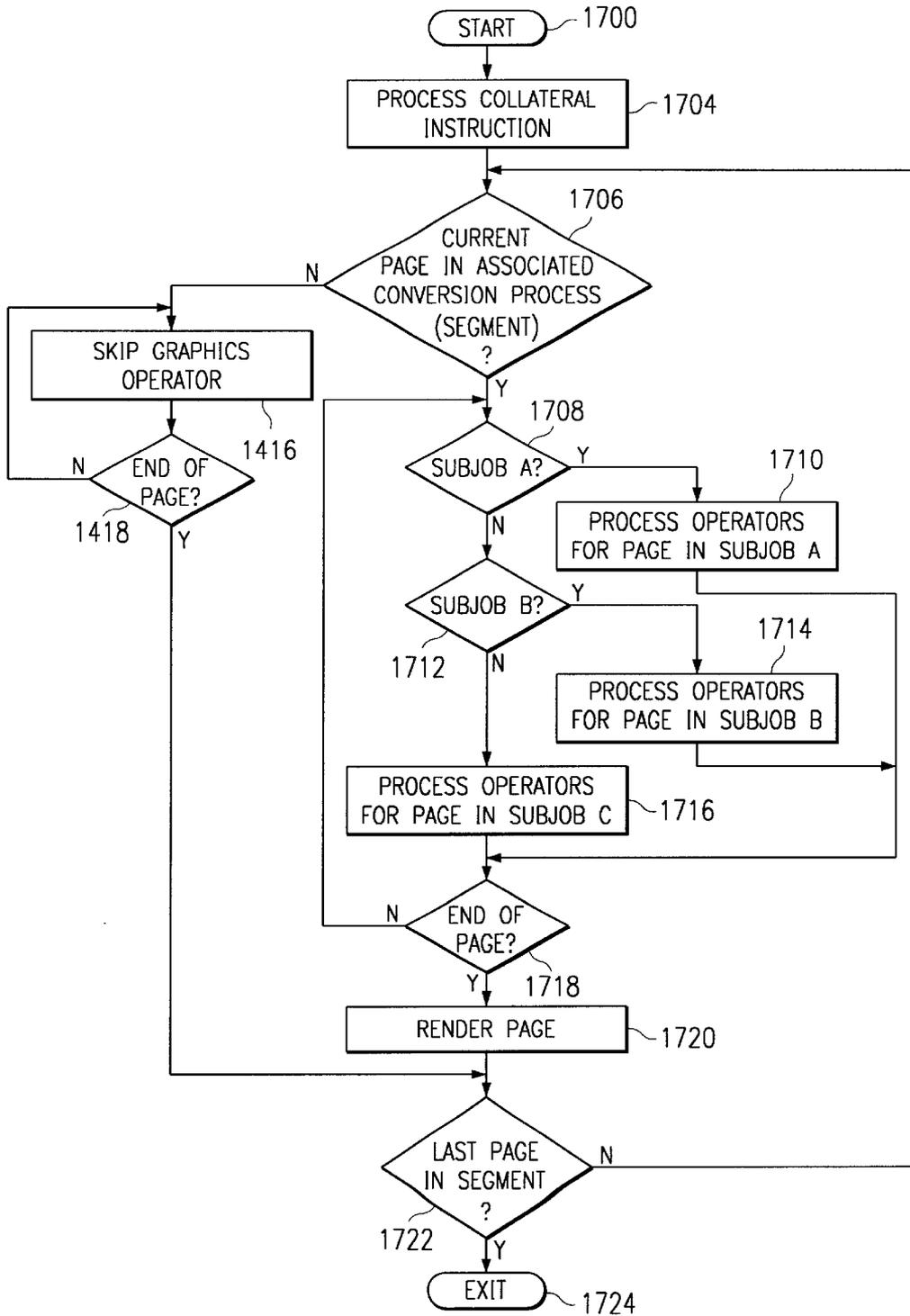


FIG. 17

## METHOD AND APPARATUS TO PERMIT EFFICIENT MULTIPLE PARALLEL IMAGE PROCESSING OF LARGE JOBS

### TECHNICAL FIELD OF THE INVENTION

The present invention pertains in general to systems of parallel printers and, more particularly, to a plurality of processors in the printing system arranged in parallel to perform conversion processing for very large jobs in a parallel manner.

### BACKGROUND OF THE INVENTION

In the area of multi-processing one of the ongoing challenges is to develop methods and workflows that lend themselves to efficient uses of parallel processing. Today one of the most popular methods for describing documents, especially for printed delivery, is the well known PostScript® produced by Adobe Systems Incorporated. PostScript® has many benefits and is almost universally employed in many print markets today. However, it has a limitation which creates a significant barrier to efficient parallel processing. That limitation is created by the fact that within a PostScript® file, the boundaries and content of individual pages is buried within the file and can only be determined by processing the PostScript® file in some manner to establish the page boundaries and content. One popular method to do this is to transform or convert a PostScript® file into a portable document format (PDF) file, typically referred to as a “distilling” operation. This allows the page boundaries in a multi-page job to be established and thus allows multiple interpreters to operate on the pages individually, thus facilitating parallel processing. However, if the object is to process a job faster, one must take into account the time necessary to convert from a page dependent format as in the PostScript® file to the desired page independent format as in a PDF file. This added conversion time will add to the overall time to complete the job.

### SUMMARY OF THE INVENTION

The present invention disclosed and claimed herein comprises a system and method for parallel conversion processing of a print job in a print system having a plurality of RIP engines, comprising the steps of: defining the print job for RIP of select portions of the print job in parallel; partitioning the print job into select portions according to defined boundaries; generating a substitute RIP instruction for each select portion of the print job; and processing the RIP requirements of each select portion in an assigned one of the plurality of RIP engines according to the substitute RIP instruction.

In one aspect of the present disclosure, the step of defining the print job comprises the steps of: spooling the print job file into storage; updating the documented information in a job control file associated with the print job file; and processing the documented information obtained from the job control file.

In another aspect of the present disclosure, the step of partitioning the print job comprises the steps of: determining whether single or multiple RIP is to be performed; partitioning the job into one or more select portions to be RIPed if a multiple RIP is to be performed, wherein at least a portion less than all of the print job is selected for processing; and defining the RIP requirements for each select portion of the print job.

In another aspect of the present disclosure, the step of generating a substitute RIP instruction comprises the steps of

configuring the substitute RIP instruction to perform RIP only upon an identified select portion of the print job; resetting the predefined operator instructions associated with the print job file as input to the print system; appending the substitute RIP instruction associated with each identified select portion of the print job to the print job; and selecting a RIP engine to perform RIP upon each identified select portion of the print job.

In another aspect of the present disclosure, the step of processing the RIP requirements of each select portion comprises the steps of distributing the print job in parallel replication, each print job replication having appended thereto a particular substitute RIP instruction associated therewith, to each select one of a plurality of RIP engines associated with the identified select portion of the print job to be RIPed in parallel; performing, in each select one of the plurality of RIP engines, the RIP of the print job distributed to each select one of the plurality of RIP engines; and rendering each select portion of the print job for which RIP according to the substituted RIP instruction was performed.

### BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention and the advantages thereof, reference is now made to the following description taken in conjunction with the accompanying Drawings in which:

FIGS. 1a and 1b illustrate a block diagram for parallel conversion processing of large print jobs according to the present disclosure;

FIGS. 2a and 2b illustrate a flowchart for the operation of the printing system of the present disclosure while performing parallel conversion processing of large print jobs;

FIG. 3a illustrates a block diagram of a prior art parsing algorithm for a parallel processing system;

FIG. 3b illustrates the conversion operation of the present disclosure;

FIG. 4 illustrates a block diagram of the parallel processing operation of the present disclosure utilizing the embodiment of FIG. 3b;

FIG. 5a illustrates a diagrammatic view of a prior art page distribution;

FIG. 5b illustrates a diagrammatic view of the page distribution associated with the embodiment of FIG. 4;

FIG. 6 illustrates an overall block diagram of the parallel processing system of the present disclosure;

FIG. 7 illustrates a diagrammatic view of the mapping operation from a PDL input job to an output device;

FIG. 8 illustrates a block diagram for an alternate embodiment of the present disclosure wherein information is inserted into the PDL;

FIG. 9 illustrates a block diagram for a distributed network for providing the parallel processing operation;

FIG. 10 illustrates a diagrammatic view of one application of the system operating over a global communications network;

FIG. 11 illustrates a block diagram for the example for a prior art parsing system;

FIG. 12 illustrates a block diagram of a simplified segmented RIP operation;

FIG. 13 illustrates a diagrammatic view of the PDL<sub>IN</sub> job in the PostScript® file format;

FIG. 14 illustrates a flowchart depicting the operation of processing through a PostScript® file;

FIG. 15 illustrates a block diagram of an alternate embodiment;

FIG. 16 illustrates a diagrammatic view of the embodiment of FIG. 15; and

FIG. 17 illustrates a flowchart depicting the operation of the embodiments of FIGS. 15 and 16.

#### DETAILED DESCRIPTION OF THE INVENTION

Referring now to FIGS. 1a and 1b, there is illustrated a block diagram of a system for performing multiple, parallel conversion processing for large print jobs. Conversion processing, by way of example, may include raster image processing (RIP). The print job input 100 is provided to a print driver 102 as a print job file 104 and is output from print driver 102 along a line 106 to a print spooler 108. Print spooler 108 includes a control file 110 for storing job control information. Control file 110 may be a storage location or it may be merely a temporary data file that travels with the print job file 104. The print spooler 108 represents storage for the print job file 104 wherein the print job file 104 may be made available along a path 112 to an instruction operator 114. Instruction operator 114 has an output along a line 116 to a distributor 118 in FIG. 1b.

Returning now to the print spooler 108 there is shown the control file 110 portion of print spooler 108 which is coupled to a language processor 120 along a bidirectional data path 122. The language processor 120 provides for extracting specific information from the control file 110 which will be used in subsequent process control functions. The language processor 120 may take several forms depending on the application. The examples to be described herein are not intended to be limiting but merely illustrative. Other examples of structures for fulfilling the functions of the language processor 120 are possible, as will be apparent to persons skilled in the art. One example of a language processor 120 is a language monitor which is programmed to recognize specified document parameters as they are spooled into the system. Such functions may also be performed by a user mode driver or a user mode graphical user interface. All of these examples are readily adaptable in a typical operating system environment such as Windows NT® produced by Microsoft® Corporation. Another example, to be described hereinbelow, provides an estimating engine such as a page estimating engine 128 which forms an estimate of the total number of pages based on certain assumptions about the print job file, e.g., that it's a homogeneous document and based upon updates as the print job file is spooled into the system. As will also be described hereinbelow, the information provided by the language processor 120 and the page estimating engine 128 is used in partitioning the print job file into select portions, and also to preserve the document parameter information required to keep the print job file accessible by the processor(s) during subsequent parallel RIP operations.

The select portions mentioned hereinabove are processed in parallel to achieve greater throughput, improved workflow and greater efficiency through more logical function organization of the processes. For example, each select portion of the print job may be treated or processed differently during RIP as required by the application. Moreover, by making assumptions or a priori guesses about the print job document parameters, other advantages besides those mentioned hereinabove may be realized. For example, the delivery of very large print jobs nationwide such as daily and weekly periodicals may be greatly facilitated by partitioning the print job file according to the zip codes of the addressees for the documents. All addressees may thus receive their

copy of the print job file as early as possible and at approximately the same time. Other document parameters that may be used include the type of material—graphics, text, blank regions, color, monochrome, and the like. For the purposes of the illustrative example described herein, the total number of pages is a practical document parameter that is a relatively easy example to illustrate the principles of the present disclosure.

In the illustrative example shown in FIGS. 1a and 1b, the language processor 120 provides extracted document parameters 124 along a line 126 to a page estimating engine 128. The page estimating engine 128 provides an output along a line 130 consisting, for example, of the total number of pages 132 which is provided along a line 134 to the instruction operator 114. In this illustrative example, the language processor has extracted document parameter information necessary for estimating the total number of pages in the print job file and providing that information to the instruction operator 114 for use in processing the print job file which is contained in print spooler 108. There is also shown an optional manual entry block 136 that provides for manually entering the total number of pages along a line 138 and coupling therealong to lines 130 and 134 to provide the information about total number of pages 132 to instruction operator 114.

In operation, the language processor 120 obtains document parameter information from the control file 110 to be used by the instruction operator 114 in defining control parameters for accomplishing the parallel conversion processing of a print job in an efficient manner. In the illustrative example shown in FIGS. 1a and 1b, the language processor 120 extracts information about the total number of pages that are spooled into the print spooler 108, feeding it to the instruction operator 114. The instruction operator 114 uses this information, for example, the total number of pages, for partitioning the total print job into portions such that each portion may be processed in a parallel conversion processing configuration. That is, the total print job may be divided into portions, each portion of which is designated for processing on an associated selected RIP engine. Alternatively, the entire print job file is sent to, i.e., made accessible to, each of a plurality of conversion engines coupled in parallel to a common bus via distributor 116. As thus sent, each one of the print job files 104 includes an apportioned (select) segment, having part of the document file allocated for full conversion in the conversion engine receiving it, and a remaining segment having the rest of the document.

The language processor 120 is also capable of extracting other kinds of information that may be programmed into the system for control of subsequent processing operations upon the print job file 104. The instruction operator 114 has the capability of reading the function operators associated with the print job file and modifying certain of the operators used to control the processing of the print job file. Together, the language processor 120 and the instruction operator 114 operate to avoid having to otherwise convert the entire document file from e.g., a PDL format to a PDF format to obtain access to the page parameters and other information stored in the header that would be required to organize the print job file for processing through conversion and subsequent stages in a parallel system. For example if the print job file 104 was formatted in PostScript®, which is a well known page description language produced by Adobe Systems Incorporated, then the instruction operator 114 can read the PostScript® operators and modify those operators that are used in the processing or can substitute other operators

or instructions in order to accomplish specific print system control features. The example given of estimating the total number of pages in the print job in order to partition the print job into portions for subsequent processing is just one example of the kinds of operations that may be performed in the system and method of the present disclosure shown in FIG. 1.

Continuing with FIGS. 1*a* and 1*b*, the distributor block 118 is provided to distribute in multiple print job files, each multiple thereof having a select portion of the print job which was segmented or partitioned by instruction operator 114 for processing according to separate processes in a plurality of parallel sections of the print system illustrated in FIGS. 1*a* and 1*b*. For example, distributor 118 provides the print job file 104 including a first select portion 140 along a line 142 to a first RIP engine 150. The first select portion 140 may include an appended instruction added by the instruction operator 114 which may represent a modified processing step or a substitute instruction for use by the first RIP engine 150 in processing the print job file. It will also be noticed that the first RIP engine 150 may include a first print engine associated with the first RIP engine 150. In other applications the first print engine may be separate from the first RIP engine 150. The output of first RIP engine 150 is provided along path 156 to an optional merge block 162 wherein the outputs of several RIP engines and/or print engines may be merged together to provide a combined print job output along path 164.

The outputs of the RIP engines 150–154 may be in different locations, such that a merge operation is not called for. Distributor 118 has several other outputs including an output for a print job file having a second select portion 144 which is coupled along path 146 from distributor 118 to a second RIP engine 152. Similarly a print job file having an *n*th select portion 148 is also coupled from distributor 118 along a path 151 to an *n*th RIP engine 154 representing the last partitioned print job file having a select portion of the print job to be separately processed in a parallel path. The outputs of the second RIP engine 152 and the *n*th RIP engine 154 are provided respectively along paths 158 and 160 to the merge block 162 for merging with other select portions of the print job which have been subject to conversion processing and printing by associated print engines, as shown in blocks 150, 152 and 154 corresponding to the respective RIP and/or print engines.

In operation, the select portions of the print job obtained by segmenting the print job file in block 114 are routed to separate, associated RIP engines by distributor 118, providing for, in this illustrative example, parallel conversion processing and printing prior to becoming merged together to complete the print job along path 164. The select portions, each of which represents less than all of the entire print job file 104, are separately processed by the RIP engines 150, 152 and 154 according to substituted RIP instructions generated by the instruction operator 114 based on document parameters 124 extracted by a language processor 120. Further, the remaining portion of each print job file sent to a conversion engine 150, 152 or 154 may be processed according to modified instruction operators appended to the print job file. Operation of these features will be described in detail hereinbelow in conjunction with FIGS. 2*a* and 2*b*. The concept of “less than all of the entire print job,” which is embedded in the segmenting or partitioning of the print job into select portions and remaining portions, will become clearer as the description proceeds.

Referring now to FIGS. 2*a* and 2*b* there is shown a flowchart for an illustrative system and method for parallel

conversion processing of a print job in a print system having a plurality of RIP engines. While the illustrative example describes the operation of a conversion engine that performs raster in each processing (RIP) it will be understood that the process illustrated in FIGS. 2*a* and 2*b* applies equally well to other conversion processes that may be substituted for raster image processing. Beginning from the start block 200, in FIG. 2*a*, the flow proceeds to a block 202 where the input print job file is spooled into the system. The flow then proceeds to a block 204 to update the job control file 110 which contains operating parameters and program operators for controlling the operation of the processing of the print job file. Block 204 has two outputs, one labeled “E”, the other labeled “U.” The path labeled “E” proceeds to a decision block 206 where the system determines whether the language processor 120 is engaged. The language processor 120 provides for extracting and utilizing the operating parameter information stored in the job control file 110. If it is found in decision block 206 that the language processor 120 is engaged then the flow proceeds along the path labeled “Y” to function block 208 where the system reads the job control file to obtain the operating parameters needed for the control of processing.

Returning to the function block 204, the second output of the function block 204 labeled with a letter U proceeds to the operation of updating the job control file 110 in function block 208, showing that the job control file will be updated and ready for use when accessed by the language processor 120. Upon reading the job control file 110 in the function block 208, the flow proceeds to a function block 210 wherein the system defines the boundaries of portions of the print job file to be selected for conversion processing in separate, parallel RIP paths. Returning now to decision block 206, if the language processor is determined to be not engaged, then the flow proceeds along the path labeled “N” to function block 214 which provides for entering the document parameters manually for use in function block 210. Block 210 operates to define the boundaries of the select portions of the print job file to be separately RIPed, which is shown by the path from function block 214 to intersect with the path that enters function block 210. The partitioning may be organized so that the page outflow order of the multiple print engines’ output is preserved. This requires a one-to-one correspondence between print engines and RIP engines. Thus, the outputs may be made collatable to avoid interleaving in a random order out of sequence. The partitioning basis, which is obtained by processing the document parameters, may also be configured to vary with or depend upon the context of the print job in some applications, or even vary with processor speed while dividing the print job file into operable portions.

Continuing now with FIG. 2*a*, once the boundaries of the select portions of the print job file have been defined in the block 210, the flow proceeds to a decision block 212 to determine whether the print job file will be processed with a single RIP or a multiple RIP. The decision to process with a single RIP or multiple RIP, which may depend on testing for a boundary condition, may typically be based on the total number of pages or other document parameters as previously described and is usually made to facilitate load balancing operations in the parallel RIP of the system and method of the present disclosure. This decision may also be made prior to entering the print job file. In general, large files will be processed using the multiple RIP capability of the print system of the present disclosure. However, if the print job is not large and can efficiently be processed using a single RIP, the system accommodates this by proceeding

along the path labeled "S" to a function block **216** to forward the print job file to RIP and print. The flow proceeds to a function block **218** to print the document. Following printing, the flow ends at a block **220**. Returning to decision block **212**, if the system determines that the print job file is large and is to be processed in a multiple RIP, then the flow proceeds along the path labeled "M" to a function block **222** where the system accesses the document parameters and the RIP requirements needed for performing the parallel RIP in the print system of the present disclosure. RIP requirements may vary with the application, depending on the particular document parameters. The RIP requirements may also be characterized as standard, full RIP or modified RIP. Modified RIP may further be delineated as accelerated RIP or no RIP. Accelerated RIP may include RIP during fast forward, low resolution or skip modes in order to speed up the RIP of certain portions of a print job file.

Following access of the document parameters and the RIP requirements from the job control file **110**, the flow in FIG. **2a** proceeds to block **224** where the system determines and identifies the range that the select portion of the print job occupies among the total pages in the entire print job file **104**. For example, if a select portion includes pages **201** to **300** in a print job file having 1000 pages, then pages **201** through **300** define the range of that select portion of the print job file that will be separately RIPed in a parallel RIP part of the process described in the present disclosure. The ability to define a select portion enables RIP of a designated, "less than all" portion of the entire print job as, for example, to insert or revise a chapter of a publication. It was described previously how the boundaries of each select portion are defined using document parameters developed and processed by the language processor **120** in block **206** and subsequent steps. Thus, a page boundary will be associated with each of the pages **201** and **300** to define the boundaries of the select portion. Along with the page boundary information will also be provided the RIP requirements associated with the particular select portion of the print job.

Returning to FIG. **2a**, the flow proceeds to a function block **226** where the system configures a substitute RIP instruction to accompany the select portion of the print job file. The substitute RIP instruction is configured and generated according to the RIP requirements and provides the instruction for performing a standard full RIP of the select portion as well as modifying the RIP to be performed on the remainder of the print job file to be processed by the particular processor that will perform the RIP for the select portion. It will be appreciated that this flowchart of FIGS. **2a** and **2b** describes the operations that are performed by the system on a single select portion of the print job file, and that each select portion for which boundaries have been defined will be similarly processed in the order in which the select portion is positional in the entire print job file. When the configuration of the substitute RIP instruction is completed in block **226** the flow proceeds to a function block **228** where the system resets the operators associated with the print job file as input to the system in block **202**. The operators which are reset are those that relate to the RIP that is required for the print job, which operators will be replaced by the substitute RIP instruction described previously. In the next step, represented by a function block **230**, the substitute RIP instruction is appended to the select portion of the print job file which will provide the instructions for the RIP by the selected processor or RIP engine.

Continuing with FIG. **2a**, there is shown in a function block **232** the step of selecting a RIP engine for each select portion of the print job file to be processed in parallel with

all of the other select portions of the entire print job file. The selection is made in the function block **232** according to the RIP instructions which associate a particular designated RIP engine to perform the required RIP of the select portion of the print job file. The flow then proceeds to a function block **234** where the system distributes each of the select portions to an associated RIP engine to perform the conversion processing step. The flow then proceeds to block **236** where the selected RIP engine reads the substitute RIP instruction associated with the select portion that it is about to process and initiates the conversion processing.

Included in the substitute RIP instruction for each select portion is the possibility of performing the RIP in three different ways. It was noted hereinabove that each processor performing conversion processing receives the entire print job along with the designation of a select portion having defined boundaries upon which will be performed a standard, full conversion processing. The remaining portions of the print job file sent to each processor may receive different treatment according to whether the processor is to ignore RIP entirely for part of the remaining portion or is to modify the RIP for some part of the remaining portion of the print job file. Thus, in a decision step **238** in FIG. **2b**, flowing thereto from block **236** in FIG. **2a**, the determination is made as to whether to ignore the RIP for the particular portion of the print job file that is presented to the processor for conversion processing. If the result of this determination is affirmative, then the flow proceeds along the path labeled "Y" to a function block **240** where the RIP engine renders no output for those particular pages, and the routine ends at a function block **242**. If, however, the result of the determination in the decision block **238** is negative, i.e., the RIP is not to be ignored, then the flow proceeds to a decision block **244** wherein the system determines whether the present pages are to receive a modified RIP. If the result of this determination is affirmative then the flow proceeds along the path labeled "Y" to a function block wherein the system **246** will render the select portion according to the modified RIP and return the operation to the decision block **244** to again make the determination on the next page to determine whether a modified RIP will be performed thereon. By way of definition the term "render" refers to the action performed by a RIP engine or a print engine in performing processing on the select portion or a remaining portion.

Returning now to the decision block **244**, if the determination is made that a modified RIP is not to be performed, then the flow proceeds along the path labeled "N" to a function block **248** where the RIP engine renders the select portion according to the substitute instruction, that is, the RIP engine proceeds to perform a full standard conversion processing upon the select portion. All RIPed pages, once having been RIPed, may be stored for re-use and/or re-processing. Flow then proceeds from the function block **248** to a decision block **250** where a determination is made as to whether the pages of the select portion subject to the standard, full conversion processing are to be printed or subjected to some other output process displayed. In the case where the RIPed pages are to be displayed, the flow proceeds along the path labeled "D" to function block **260** where the system proceeds to send the select portion of the print job file to a display in the system, and the flow then proceeds to a function block **262** for the actual display of the select portion pages. Following the display the routine ends in a function block **264**. Returning to decision block **250**, if the result of the determination is to print the select portion of the print job file, then the flow proceeds along the path

identified "P" to a function block 252 wherein the system proceeds to send the select portion of the print job file to the print engine that will print the particular select portion. The flow proceeds to a function block 254 wherein the print engine will be controlled to print the select portion which is followed by the action in a function block 256 where the printed outputs of each of the print engines receiving select portions for printing are merged into the completed document. Following merging of the printed outputs the routine ends at a function block 258.

Returning to decision block 250, if the result of the determination is to select "other" as the output, then the flow proceeds along the path identified "L" to a function block 253 to select a different output, different from a print operation or display operation. This alternate output in block 253 could be an output such as storing the information, sending it as mail, transmitting it over the Internet to another and remote location on the Internet or in general routing it to some other location for some other operation. It should be understood that any type of operation could result at decision block 250. After the operation in function block 253 is complete, the program proceeds to the End block 258.

Referring now to FIG. 3a, there is illustrated a simplified block diagram illustrating the prior art operation wherein an input PDL job, PDL<sub>IN</sub> is distributed to parallel marking engines 302 labeled ME<sub>1</sub>, ME<sub>2</sub>, ME<sub>3</sub> and ME<sub>4</sub>. The input language is defined as a PDL input, PDL<sub>IN</sub>, this document being a page delineated document such as PostScript®. However, it could be any other type of electronic data file that has contained therein pages of information, which pages of information can be extracted therefrom.

The PDL<sub>IN</sub> job is processed through a PDL converter 304 which is operable to provide on the output thereof a PDL<sub>OUT</sub> document. The PDL<sub>IN</sub> comprises n pages of information, as does the PDL<sub>OUT</sub> document. Therefore, the PDL converter 304 is operable to convert the entire PDL<sub>IN</sub> document to the PDL<sub>OUT</sub> document. In one example, the PDL converter 304 could comprise a PDF Distiller that is operable to receive a PostScript® document and convert it to a PDF document. The advantage of a PDF document is that the PDF document is delineated in pages such that only a desired number of pages can be extracted therefrom, with each page not requiring information regarding another page or information in the file. This is to be compared with a PostScript® language file, wherein the job must be completely processed in a sequential order to the last page at the end of the job, due to the fact that there are instructions embedded throughout the PostScript® file associated with the n pages that may be necessary to process the last page or any page therein. Therefore, conventional processing requires that the entire job be processed.

Once the PDL<sub>OUT</sub> document is derived from the PDL<sub>IN</sub> job, this PDL<sub>OUT</sub> job is then processed through a Parser 306 to derive multiple processing segments, S<sub>1</sub>, S<sub>2</sub>, S<sub>3</sub>, S<sub>4</sub>, which are all input to respective ones of the marking engines 302. The primary disadvantage to the prior art system is that the PDL converter 304 must process the entire n pages associated with the PDL<sub>IN</sub> document before the document can be parsed.

Referring now to FIG. 3b, there is illustrated a diagrammatic view for a single engine output in accordance with the present disclosure. The PDL<sub>IN</sub> document, comprised of n pages, is input to a PDL converter 310, which PDL converter 310 is operable to process the entire PDL<sub>IN</sub> document, but output less than n pages as the PDL<sub>OUT</sub> output for a given segment of the job. These segment pages are then processed

by a marking engine 312, which also could be a display, it being understood that the marking engine or display 312 is representative of any type of output device. This will then provide an output which could be a viewable display or a paper output.

Referring to the foregoing FIG. 3b, consider that a selected portion or segment S<sub>1</sub>, S<sub>2</sub> . . . S<sub>n</sub> of each of the input document files is defined before any subsequent conversion processing. The function that performs the subsequent conversion processing, although it has access to the entire document file in PDL converter 310, only operates on the selected portion or segment of less than n pages of the entire document file. When a document is segmented into several segments or selected portions, the subsequent conversion processing, e.g., in the marking engine 312 (or in a display engine 312 in the alternative) follows the segmentation and distribution of the segment(s) to the subsequent processor. The subsequent processing, then, in a post-distribution processing; here, occurring after distribution of the corresponding multiple of a document file (having an identified select portion of the document file to be subject to the post-distribution processing) to the conversion engine to which the document file was distributed. Typically, the subsequent processing is a conversion of the document file, but instead of converting the entire file, only a segment or select portion of it is actually converted—a select portion "less than all" of the n total pages—in each subsequent conversion processor. Thus, parallel processing of multiple document files, and the corresponding select portions thereof. In a plurality of parallel processors, the following distribution has the capability of a substantial reduction in conversion and processing time because (a) the entire "input" conversion 304 is eliminated and (b) the PDL conversion in PDL converter 310 (regardless of the particular type of conversion being performed therein) of each of the individual select portion(s) of the document file PDL<sub>IN</sub> may be performed in parallel.

Referring now to FIG. 4, there is illustrated a block diagram of a parallel processing system utilizing the embodiment of FIG. 3b. The PDL<sub>IN</sub> job, an n-page document, is provided on an input 402. This input in the form of the document is distributed to a plurality of PDL converters 404, there being "M" PDL converters, PDL<sub>1</sub>, PDL<sub>2</sub>, . . . , PDL<sub>M</sub>. Each of these PDL converters 404 is operable to process the entire PDL<sub>IN</sub> document, but only process the PDL<sub>IN</sub> document to output a number of pages that is less than the n pages for the associated segment. This provides on an output 406 a PDL output signal for segments S<sub>1</sub>, S<sub>2</sub>, . . . S<sub>M</sub>. Each of these segments is less than n pages, and can be different portions of the file or job, as will be described hereinbelow. Each of the outputs is then processed by an output device in the form of a marking engine, as an example, there being M marking engines 410 labeled ME<sub>1</sub>, ME<sub>2</sub>, . . . M<sub>M</sub>. Each of these marking engines 410 provides an output after processing thereof. As described hereinabove, for a marking engine output, the conversion operation comprises a RIP operation to provide a RIPped document that can then be forwarded to the marking engine. Therefore, the PDL conversion operation is one of providing a bit mapped RIPped file or output. However, it should be understood that the conversion operation in the PDL converters 404 could convert PostScript® to PDF, PostScript® to html or PostScript® to a display language. Also, any of the languages could be converted to any of the other languages. One aspect of the converters running the conversion processes is that, during the conversion operation, they receive the entire file and convert only the

portion thereof necessary to provide on the output thereof a document in another PDL format with a number of pages contained therein that constitute less than the total number of pages to the input job in the input PDL format.

Referring now to FIG. 5a, there is illustrated a diagrammatic view of the conversion operation for the prior art system of FIG. 3a. The PDL<sub>IN</sub> document is illustrated as having information in the form of a header and a plurality of pages, P<sub>1</sub>, P<sub>2</sub>, P<sub>3</sub> . . . P<sub>n</sub>. This constitutes the n pages of the document. The header, represented by a block 502, constitutes the information that is required for processing. In some document files, such as PostScript®, this may require a large number of instructions. Further, although the header 502 is illustrated as being at the beginning of a job, it should be understood that the information in the header could be distributed throughout the job. For example, in PostScript®, there are certain instructions that do not occur until they are necessary. For example, when a color correction is indicated in the middle of the document, certain instructions may occur which are required for later processing. Further, certain instructions in prior pages could be changed at a later portion in the instruction set. Therefore, it is important that all of the instructions be executed during the processing of the job, at least prior to the last page in the segment to be processed.

In the conversion operation, indicated by a line 504, the entire document is processed to the PDL<sub>OUT</sub> document which is also comprised of P<sub>1</sub>, P<sub>2</sub>, P<sub>3</sub>, . . . , P<sub>n</sub> pages. Each of these pages can then be divided into segments, as indicated by segments 506, S<sub>1</sub>, S<sub>2</sub>, S<sub>3</sub>, . . . , S<sub>M</sub>. It is noted that the PDL<sub>OUT</sub> document is one that facilitates segmentation into separate pages i.e., it is possible to extract the pages therefrom. One example of this is a PDF formatted document. However, the conversion operation 504 requires that the entire PDL<sub>IN</sub> document be processed and converted into n pages. Therefore, if only the pages associated with segment 506 labeled S<sub>1</sub>, then a significant amount of processing is required in the conversion operation 504.

Referring now to FIG. 5b, there is illustrated a diagrammatic view of the embodiment of FIG. 4. The same PDL<sub>IN</sub> document 502 is provided with the same header 502. This document is distributed to a plurality of conversion operations, this distribution being provided via tree structure 510. This is a virtual distribution, as will be described hereinbelow. There are provided a plurality of separate conversion operations for each segment, an S1 converter 512, an S2 converter 512, . . . , an SM converter 512. Each of these converters 512 operates upon the entire PDL<sub>IN</sub> job. However, it processes only the information necessary to process its particular segment, S1, S2, . . . , SM. In the S1 conversion operation, there is illustrated a segment 514 which comprises the pages P1, P2, . . . , PS1-E, the page PS1-E indicating the last page in the document wherein the page P1 is the first page in the segment. It is noted that all pages after PS1-E up to page Pn are not processed. In the S2 conversion operation, there is provided a segment 516 which is comprised of a beginning page PS2-I, the initial page, to PS2-E, the last page in the segment. This segment begins after the first page and prior to the last page Pn. The SM conversion operation is associated with a segment 518, which is initiated at a segment PSM-I which extends through a last page, Pn. Although illustrated as being segmented from an initial section of the document to the last section of the document, these segments could be distributed in any manner.

Each of the conversion operations 512 is operable to provide an output to an output device, in this example, a

marking engine 516, there being illustrated M marking engines, ME<sub>1</sub>, ME<sub>2</sub> and ME<sub>M</sub>. However, as described hereinabove, this output could be to a file, to a display or even to a network.

Referring now to FIG. 6, there is illustrated an overall block diagram of a distributed processing system. In this device, there is provided a job source 602 for generating the PDL<sub>IN</sub> job, which is processed through a block 604 and is operable to interface with a storage device 606. For example, the job source 602 could generate the job as a PostScript® file, with the block 604 controlling the storage thereof in the storage device 606. This job could be a very large job. The storage media 606 is interfaced with a plurality of conversion engines 610, labeled CONV 1, CONV 2, CONV 3, . . . , CONV M. Each of these conversion engines 610 has access to the storage database 606 through the PDL<sub>IN</sub> job block 604 through distribution network 612. When the job is initially generated, a user will provide instructions through a user input block 616. The user could provide a priori information as to the number of pages that are to be processed, and how they are to be processed. As described hereinabove, this could be an automatic operation wherein the PostScript® file could be examined prior to processing to determine how it is to be processed. However, this information can be supplied by the user. This information is stored in an instruction register 618. A distribution engine 620 is provided, which distribution engine is operable to parameterize each of the conversion engines 610 to define what segments they are to process. As described hereinabove, each of the conversion engines 610, in order to process its associated segment, will require access to the entire PDL<sub>IN</sub> job that is being processed.

Each of the conversion engines 610 has associated therewith a database 622 which allows for storage of the converted job, if necessary. Therefore, each of the conversion engines 610 could store the converted output thereof. The conversion engines 610 are labeled CONV 2, CONV 3, . . . , CONV M, each having the output thereof provided to an associated output device 624, labeled Output Device 2, Output Device 3, . . . , Output Device M, respectively. However, the conversion engine 610 labeled CONV 1 has its output temporarily stored in the database 622 such that the PDL<sub>IN</sub> job is converted to a PDL<sub>INT</sub>, an intermediate PDL job. This PDL job is then input to second tier conversion engines 626, labeled CONV 1a and CONV 1b. Each of these conversion engines 626 is operable to operate only on a portion of the PDL<sub>INT</sub> job and provide the output thereof to an output device 628 labeled Output 1a and Output 1b. This tiered operation could be any combination of levels, it being understood that the processing operation in any of the conversion engines 610 or 626 operates on less than all of the n pages associated with a prior conversion engine receiving and operating upon the original PDL<sub>IN</sub> job. Of course, any other conversion engine could operate on all of the pages, it being understood that at least one of the conversion engines can operate on less than all of the pages to increase the throughput.

Referring now to FIG. 7, there is illustrated a diagrammatic view of the mapping operation for a single conversion operation. The PDL<sub>IN</sub> job has associated therewith a plurality of pages, this being a ten page job, having pages P1 through P10. This job has associated therewith a header 704, which header 704 comprises all of the non-graphic information for the pages. It should be understood that some of the overhead required is information such as page start, page end and instructions about a page that really do not constitute the graphics but, rather, constitute instructions to the

output device as to how to handle the information during processing thereof and conversion thereof.

In the illustration in FIG. 7, there is provided a mapping block **706** which is operable, under the control of the distribution engine **620**, to map the particular pages to the conversion operation, this merely constituting instructions to the conversion engine. There are provided four conversion engines **708** labeled **S1 CONV**, **S2 CONV**, **S3 CONV** and **S4 CONV**. In the illustration of FIG. 7, the **S1 CONV** conversion engine **708** has mapped thereto pages **P1**, **P2**, **P3**, **P4** and **P5**. The **S2 CONV** conversion engine **708** has mapped thereto pages **P1**, **P2** and **P3**, the **S3 CONV** conversion engine **708** has mapped thereto pages **P5**, **P6** and **P8** and the **S4 CONV** conversion engine **708** has mapped thereto pages **P4**, **P5**, **P6**, **P7**, **P8**, **P9** and **P10**. Therefore, it can be seen that the distribution engine **620** can map any number or combination of the pages in the original job to any one of the conversion engines **708**. It should also be understood that each of the conversion engines **708** operates independent of the other conversion engines **708** in that it has associated therewith a certain portion of the input job to process and the remaining portion of the job is ignored.

Referring now to FIG. 8, there is illustrated a diagrammatic view of an alternate embodiment of the present invention illustrating only a single processing operation. The PDL<sub>IN</sub> job is provided in a block **802** which is then input to a summing junction **804**. The summing junction **804** is operable to sum new PDL information or merge new PDL information from a block **806** with the original PDL input job. Therefore, this effectively converts a job and provides as an output a converted job in the same PDL format. For example, it could be that information in the form of graphics were required to be added to each page in the PDL<sub>IN</sub> job. It could be that the nature of the PDL job would be changed, for example, from a color job to a black and white job. This summing junction **804** in essence is a conversion operation which requires introduction of instructions or extraction of instructions therefrom. In any event, there is provided on the output of the summing block **804** a converted PDL<sub>IN</sub> job in the same PDL format. If the job were originally in PostScript®, it would still be in PostScript®, albeit with the new information merged therewith. Further, the output of the summing block **804** comprises all n pages of the document.

The output of the summing block **804** or the output of the PDL<sub>IN</sub> block **802** without a conversion or merge operation, is then input to a segment conversion block **810** representing the PDL conversion described hereinabove of less than n contained in the original document. This conversion operation can occur in such a manner that new PDL information is merged therewith from a block **812**. The block **812** is input to a summing block **814** illustrating the merge operation, and the output of the conversion operation from the segment converter **810** is also input thereto. Therefore, each of the pages can be processed by the conversion engine **810** to provide a converted PDL output less than n pages with merged information therein. This operation can occur in a first method wherein the conversion operation fully converts the n-1 pages and then the merge operation occurs. However, it could be that the merge operation occurs during the processing such that the conversion operation in the block **810** does both conversion and merging at the same time. This would facilitate faster processing and higher throughput.

Referring now to FIG. 9, there is illustrated a block diagram of an alternate embodiment of parallel processing in accordance with the present disclosure wherein the conversion operation is performed on remote locations on a network.

The PDL<sub>IN</sub> job is disposed at a first node **902** on the network such that the PDL<sub>IN</sub> job is stored in a database **904** and is accessed therethrough with a job block **906**. This job block **906** represents all of the instruction sets, distribution controls, etc. associated with the embodiment of FIG. 6 and with the node **902**. The distribution operation is facilitated over a network **908** to a plurality of remote nodes, there being illustrated three nodes **910**, **912** and **914**. Each of the nodes **910-914** has an interface **916** with the network **908** and a local database **918**. The local databases **918** of each of the nodes **910-914** are operable to store the PDL<sub>IN</sub> job **904**. In operation, the entire PDL<sub>IN</sub> job would be transferred from the database **904** to the local databases **918**. In addition, instruction sets defining the instructions that are to be carried out or the segments that are to be processed by each of the nodes **910-914** are transferred from an instruction register **922** at the node **902** to a distribution engine **924** associated with each of the nodes **910-914**. The distribution engines **924** are operable to determine how the job is processed at each node. Typically, this will be appended information to the PDL<sub>IN</sub> job that is transferred thereto, but it could be transmitted as a separate operation.

At each of the nodes **910**, there is provided a conversion engine **926** that is operable to be controlled by the associated distribution engine **924** to operate on the PDL<sub>IN</sub> jobs stored in the local database **918** to provide a PDL<sub>OUT</sub> converted document on the output thereof comprising less than all of the n pages in the original PDL<sub>IN</sub> job. Each of the nodes **910-914** has associated therewith a separate output device **928** for final processing thereof, this being a marking engine, a storage device or a display.

As can be seen in the operation of the embodiment of FIG. 9, each of the processing engines **926** requires the entire PDL<sub>IN</sub> job to be transferred thereto and stored in order to process the particular segments associated therewith. If the prior art system were utilized, then the PDL<sub>IN</sub> job would first require conversion to a format that would allow only the pages that are being processed at the node to be transferred thereto over the network **908**. Utilizing the system of the present disclosure illustrated in FIG. 9, the step of processing the entire PDL<sub>IN</sub> to the intermediate format is eliminated.

Referring now to FIG. 10, there is illustrated one application of the parallel processing system of the present invention. There is provided a global communication network **1002** which is a network of a plurality of computers, routers and various links that allow information to be independently transferred between locations on the network. This typically requires a computer at one location to send a TCP/IP packet of information to the network that is routed to another location which then handles this packet and forwards information back to the originating computer in return. It is the transfer of these packets that constitutes the communication link. Although this is virtually real time, there is no actual direct connection, but merely a relaying of packets over a particular route that is defined on the network. The global communication network (GCN) **1002** is typically referred to as the "Internet."

There is provided a user node **1004** and a vendor node **1006** on the network. At the user node **1004**, there is provided a user PC **1008** having a network interface **1010** to facilitate interface with the network **1002**. The user PC **1008** has associated therewith a display **1012** and a database **1014**. In addition, the user has an application **1016** associated therewith, which application is typically a browser software application. This browser application allows the user to send instructions to another node on the network, to receive

information and to in general interact with the network and remote nodes thereon.

At the vendor node **1006**, there is provided a control PC **1020** which is operable to interface with a PDL job block **1022**. The PDL job block **1022** can be controlled to access a select one or select ones of a plurality of PDL jobs stored in a database **1024**. These typically are stored in one particular format, the PDL<sub>IN</sub> format. The control PC **1020** interfaces with the network **1002** through a network interface **1026**. This control PC **1020** is operable to receive requests from the user PC **1008** for information and effect a communication therewith through a TCP/IP interconnection. Once the interconnection is facilitated, the user at the user location **1004** can then request information in the form of all or a portion of certain jobs for output on the display **1012** at the user's location or even on a printer **1026**.

In the embodiment of FIG. **10**, the vendor at the vendor location **1006** provides two conversion operations, the first conversion operation in a conversion engine **1028** and a second conversion operation in a second conversion engine **1030** to interface with the network through the network interface **1026**. There is also provided a third conversion operation in a conversion operation **1032** that is a local conversion operation. This conversion engine **1032** is operable to provide the above disclosed conversion for output to a marking engine **1034** to provide an output **1036**. All of the conversion engines **1028**, **1030** and **1032** are interfaced with the control PC **1020**.

The conversion engine **1028** and the conversion engine **1030** are operable to operate on different portions of the job that is processed and retrieved from the database **1024** by the PDL job block **1022**. In this embodiment, the user can request a certain segment of information which can be provided thereto by the conversion engine **1028** in a first PDL format PDL<sub>OUT1</sub>, whereas the conversion engine **1030** can provide the output in a PDL format PDL<sub>OUT2</sub>. In one example, a user may request information regarding a document such as a book. This book is delivered in two ways. In the first way, the book is downloaded over the network **1002** in either an HTML output for storage and reading thereof, or in a printed output. The second mode is to have it delivered to the purchaser via a land based mail carrier, wherein the conversion engine **1032** will provide the printing operation through the marking engine **1034**. However, the user may wish to preview a sample of this document. In this operation, the vendor **1006** does not wish to process the entire job merely to allow the user to sample a few pages out of a very large document. If the book were 1000 pages in length and the vendor merely wanted to allow the user to review the first ten pages of the book, the table of contents or even the first page of a given chapter, this could be facilitated with the conversion engine **1028**. This would allow the vendor **1006** to provide to the user a document (in the form of an HTML file) that is less than all pages in the main PDL<sub>IN</sub> document by converting the document in accordance with the present disclosure. For example, the introductory page, table of contents and the first one or two pages of each chapter could be converted into a single HTML document and forwarded to the user PC **1002** for output on the display **1012**, i.e., which is facilitated with the use of a browser application over the GCN **1002**. Thereafter, the user could request downloading of the entire document, which could be facilitated with the conversion engine **1030**. This could be provided in an HTML format or it could be provided in a printer language. If the user had utilized one printer language known at PCL5, a language associated with Hewlett Packard® printers, this document could be provided in that

particular printer format for direct output on the printer **1026**, or any other format that facilitates output on the printer **1026**. It is noted that a RIP output probably would not be acceptable for transferring to a user's PC for transfer to a marking engine, as few consumers possess that capability.

By utilizing the conversion engine **1028** of the above disclosed conversion operation wherein the entire input PDL job is converted to a particular page delineated format for an output document of only select pages of the n pages of the original document, throughput can be increased. This could be compared to a situation wherein the vendor would be required to convert all of his jobs initially into a format such as PDF for storage thereof and later retrieve only a segment, convert the entire job to PDF when requested and only output a certain number of pages, or utilize the above described disclosure for converting only a portion thereof on the fly. It would be undesirable for a publisher with a large number of documents to have all of these documents converted to a PDF format for access by a user. The reason for this is that some of these documents may be accessed very rarely. One advantage of electronic storage is that the inventory is substantially zero and the primary cost is throughput.

In the above disclosure utilized for parallel processing to provide segmented operation wherein segmented operation is associated with an output RIP, the present disclosed embodiment is compared to the prior art wherein there was a distilling operation or a parsing operation. In the present disclosure, the entire job is processed wherein only certain portions of the job are output such that the portions that are not output have the effect of increasing the processing speed for the particular segment. The performance of the two approaches will be compared, the first being the preparsing or prior art system and the second being the segmented RIPs, wherein the RIP is the output PDL language, it being understood that other PDL languages can be provided as the output language. In the pre-parsing language such as converting the entire job or document from Postscript® to PDF and then Ripping the job, a job is processed consisting of n pages with the total time, T, to parse from Postscript® to PDF, RIP the job and then merge the separately RIPPed pages together is defined by the following relationship:

$$T=Mn+nP+(n/N)S$$

where:

M is the rate at which pages are merged after RIPPING in sec/page;

P is the speed with which pages are distilled or parsed in sec/page;

N is the number of conversion engines; and

S is the rate at which the RIP can rasterize the pages in sec/page.

Referring now to FIG. **11**, there is illustrated a diagrammatic view of this equation for pre-parsing. It can be seen that the n pages are input to a distiller **1102** which is operable to distill at a rate of P sec/pages. For n pages, this will require a time of nP. This will provide on the output thereof segments to two RIP engines, in this example, a RIP engine **1104** and a RIP engine **1106**, each of which is operable to RIP at a rate of N sec/page. There are provided N pages to each RIP engine **1104** and **1106**, it being understood this can be segmented in a number of different ways. Each RIP engine **1104** and **1106** will take (n/N)s seconds to RIP the pages associated therewith. These will then be output to a merge block **1108** which will merge at a rate of M sec/page for a total merge time of Mn. This will provide the total time.

For the segmented RIPping, the following relationship will exist:

$$T = Mn + (n/N)S + (n - n/N)L$$

where:

L is the rate at which the RIP can rasterize and not output a low resolution, non-rendered, quick version of the page n Sec/page.

It can be seen that when,

$$(n - n/N)L = nP$$

the performances is equal for the two approaches. This assumes that  $n \gg N$  and the number of pages is known (approximately) prior to RIPping such that the RIP page setup switch time can be ignored. From this relationship, it can be seen that "quick RIPping" or advantages derived from not processing the graphic portions of certain non-selected pages during processing of the entire PostScript® file will result in a savings of time at each RIP engine. This is due to the fact that the parsing operation to derive the page has been deleted.

Referring now to FIG. 12, there is illustrated a block diagram of the operation for segmented RIPping. The n pages are forwarded to two conversion engines 1202 and 1204 which are operable to convert less than all of the n pages, that being the N pages, this being equal for the two conversion engines for this example. This will then be input to RIP engines 1206 and 1208, respectively for the output of the two conversion engines 1202 and 1204. Each of these RIP engines will operate similarly to RIP engines 1104 and 1106, in that they will RIP at a rate of S sec/page. The output will then be input to a merge block 1210 similar to merge block 1108 for merging thereof.

If the operation of the two procedures, the pre-parsing and the segmenting RIP, are compared with two or four RIPs, it can be seen that for two RIPs the parsing speed to the distiller must be twice as fast as the high speed RIP mode to the segmented approach to equal the latter in overall performance. If there are four RIPs, then the parsing operation must be 30% faster than the high speed RIP mode to offer an overall performance benefit. As N becomes very large (many RIPs), the faster method is determined solely by a comparison of the speed of the "high speed RIP mode" compared to the distiller speed.

Referring now to FIG. 13, there is illustrated a diagrammatic view of the PDL<sub>IN</sub> job, in the PostScript® file format. In PostScript® format, there is provided a file that is basically a sequence of instructions. In order to operate on a page basis, the system must be able to discriminate pages. However, in PostScript®, for example, if one were to define where the page began and only process the information associated with an instruction at the page beginning to an instruction at the page end, it might be that certain instructions that preceded that page were necessary for the overall processing operation. This is the specific case with respect to PostScript®. This is why instructions for the entire document must be executed such that n pages at the input will result in n pages at the output of any conversion operation between two PDL languages in the prior art.

With further reference to FIG. 13, it can be seen that there is provided some header information 1302 which is basically a sequence of instructions. Following the instructions would be page information. There are illustrated two pages, a first page 1304, and a second page 1306 embedded within the document. Each page has associated therewith operators that define the page start instruction or operator, some page

instructions or operators associated with the content of a page as to how it is to be rendered, page graphics and a page end instruction or operator. When the conversion engine is processing through the file, it will sequentially execute the instructions from the beginning until it reaches a page start instruction or operator. At this page start instruction or operator, the next instruction or operator will provide information as to what page number it is and various instructions associated therewith. This can be examined to determine if the page is within the range of operation, i.e., if the page is within the defined segment. If not, then the system can skip all the way to the page end instruction, thus skipping the page graphics. This is where the time saving exists, this referred to as the "quick RIPping" operation. This operation allows the conversion operation to skip the time required to convert this portion of the document into an output PDL format. This skipping can continue until a page start operation is encountered that is within the range of operation. At the end of the range, it will continue to skip pages. However, it is noted that the entire document will be processed in order to ensure that all instructions associated with rendering the page are extracted from the file. Once the last page in the range has been received, then the operation can skip to the end of the document without actually going through the remaining portion thereof.

Referring now to FIG. 14, there is illustrated a flowchart depicting the operation of processing through a PostScript® file. This is initiated at a block 1400 and then proceeds to a block 1402 to process the collateral instructions. These collateral instructions constitute the header information that is not associated with the actual graphics of the page. The program will then flow to a decision block 1404 to determine if the current page is in the range, this occurring when the page start operator is encountered. If so, the program will flow along a "Y" path to a function block 1406 to process the operators for the page, i.e., render all of the graphics. The program continues to process the operators until the end of page command where the associated instruction operator indicating the end of the particular page is encountered at a decision block 1408, and then the program proceeds to a function block 1410 to render the page. The program then proceeds to a decision block 1412 to determine if this is the last page in the range of the particular segment being processed. If not, the program will continue back to the input of function block 1402 to again process any collateral instructions that may be interspersed between pages and then to the next page to determine if it is still in the range. When all of the pages in the range have been processed, the program will flow to an EXIT block 1414. This constitutes the decision that the segment is complete, whereas the decision block 1404 determines whether a particular page is within the range, i.e., whether it is part of the segment. For example, it may be that page 4, page 5 and page 7 are processed in a segment such that it is important to skip pages 5 and 6. When this occurs, the program will flow from decision block 1404 along a "N" path to a function block 1416 to skip the graphics operators for those pages, i.e., this providing the savings in processing time. The program will then flow to a function block 1418 to determine if this is the end of the page, i.e., whether all graphics operators have been skipped. Once this is achieved, the program will flow to the input of decision block 1412 and continue processing.

Referring now to FIG. 15, there is illustrated a diagrammatic operation of an alternate embodiment of a process for converting one PDL language into another PDL language. The PDL<sub>IN</sub> job is illustrated as having a header and N pages, as described hereinabove. This is indicated by a reference

numeral **1502**. The PDL<sub>IN</sub> job **1502** is in a first PDL language, this being the input PDL language. This is to be converted to an output PDL language by a PDL conversion block **1504**, as was described hereinabove. In this example of FIG. **15**, only a single PDL conversion is performed. Also as described hereinabove, the PDL conversion **1504** operates in conjunction with various process conversion parameters **1506** which are input by the user. These are basically the instructions that were described hereinabove with respect to FIG. **6** as stored in the instruction register **618**. This is provided by user input **1508**. In general, whenever a user applies an input, this input defines, first, the segments that are to be distributed to different conversion processors or engines and, second, how that conversion processor is to operate on the whole job to extract the particular pages or information therefrom, in accordance with the stored parameters or instructions.

In the embodiment illustrated in FIG. **16**, the conversion process parameters **1506** define various "subjobs" associated with the particular segment that is to be converted by the conversion process **1504**. It may be that all the pages are to be converted by this conversion process. However, in this embodiment, the parameters define which page is associated with which subjob for output. As an example, the PDL<sub>IN</sub> document could be a postscript job and the PDL<sub>OUT</sub> document could be a PDF document. However, when performing the conversion, the PDL conversion block **1504** has the ability to examine each page and the operator associated therewith to determine how to operate on that page and essentially "render" the output. During this examination process, the operators that are stored within and integral with the PDL<sub>IN</sub> job can be reviewed to determine certain aspects of the page. As an example, if a PDL<sub>IN</sub> document had associated therewith various color pages, various black and white pages and pages of different resolutions, it may be desirable to output them to separate marking engines or to separate displays. In the marking engine example, wherein the PDL<sub>OUT</sub> document is a rasterized image, all color pages would be output to a color marking engine, all black and white pages would be output to a black and white marking engine and possibly pages having contone images could be output to a third marking engine. This is illustrated in FIG. **15** wherein there are provided three subjob blocks **1510**, labeled "Subjob A," a subjob block **1512** labeled "Subjob B" and a subjob block **1514**, labeled "Subjob C." Each of these subjobs **1510-1514** are output to an associated subjob output blocks **1516**, **1518** and **1520**, respectively, labeled "Subout A," "Subout B," and "Subout C." Further, these outputs could be memory for storage and later retrieval therefrom. It is only noted that the conversion operation performed by the conversion block **1504** provides a conversion from one PDL format to another PDL format with the distribution performed at the output thereof based upon aspects of the job during the conversion process. During the conversion process, provided by the PDL conversion block **1504**, it should be understood that it may be parameters associated with the input PDL document, PDL<sub>IN</sub> or the output PDL document, PDL<sub>OUT</sub>, that allows discrimination to be achieved. It may be that operators in the Postscript® job more easily facilitate a determination as to whether a job is a color job or a black and white job, or it may be the output PDL language that facilitates this determination. In any event, once the conversion process parameters are provided by the user in the conversion process parameter block **1506**, the PDL conversion block **1504** can make this discrimination based upon a page-by-page basis during the conversion process on the portion of the entire job that is being handled by the PDL conversion block **1504**.

Referring now to FIG. **16**, there is illustrated a diagrammatic representation of the embodiment of FIG. **15**. In this illustration, the entire job is output to the PDL conversion block **1504** and to other conversion blocks as well. The conversion block **1504** operates on the number of pages that are defined by the conversion process parameters **1506** associated with that PDL conversion block **1504**. This, as described hereinabove, can be any combination of parameters. It could be that all color pages in a certain range go to one subjob, all black and white pages within the same range go to another subjob, or the subjobs could even have different ranges within the segment. It should be understood that the PDL conversion block **1504** must operate on substantially all instructions from the initial portion of the job to each successive page, the speed benefit being realized through skipping graphic operators in pages that are not associated therewith, as described hereinabove.

The PDL document **1502** is forwarded to the conversion process and then operated on to provide the various outputs. As illustrated in FIG. **16**, the file is associated with the document is processed in accordance with the embodiment described hereinabove from a header **1602** through to a first page associated with the Subjob A block **1510**, PSJA-1. This is processed as described hereinabove, such that all graphics operators are processed and then the page allowed to be rendered by outputting it to the Subout A block **1516**. The system will proceed to the next page that is in the document, this being PSJB-1 in the present illustration, the first page in the Subjob B block **1512**. This is processed and rendered for output to the Subjob B block **1518**. The next page in the document to be encountered is associated with the Subjob A block **1510**, page PSJA-2, which is also forwarded to the Subjob out A block **1516** and then processing proceeds to page PSJB-2, PSJB-3, pages **2** and **3** for the Subjob B block **1512**, and then to the first page in the Subjob C block **1514**, a page PSJC-1. This is output to the Subout C block **1520**.

During processing, the PDL conversion block **1504** will process all operators associated with the operation of rendering the page. However, it could be that a second tier of parallel processing were provided wherein, once the page information were determined to be desirable, this page information, i.e., the graphics operators, could be output to a separate processor, which processor would be associated with the subjobs blocks **1510-1514**, one processor for each of the Subjob blocks **1510-1514**. Therefore, the PDL conversion block **1504** would merely process through the pages to determine which pages are to be operated on and the graphics operation associated therewith delegated out to the Subjob blocks **1510-1514**.

Referring now to FIG. **17**, there is illustrated a flowchart depicting the operation of the embodiments in FIGS. **15** and **16**, this being substantially similar to the flowchart of FIG. **14** described hereinabove. The flowchart is initiated at a start block **1702** and then proceeds to a function block **1704**, similar to function block **1402** to process collateral instructions. The program then proceeds to a decision block **1706**, similar to decision block **1404**, to determine if the current page is associated with the conversion process being performed, i.e., whether it is associated with the segment. If it were merely a range of pages, this would only require determining if the current page was in the range. However, other parameters can be utilized to determine whether this page is associated with the conversion process. For example, it could be that a conversion process requires all pages that had color information contained therein be output to a display, or base the selection upon the actual content in the page, i.e., examine the contents of the page in the input PDL

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format and only render the page if the content thereof was associated with the selection criteria. If it is determined that the current page is associated with the particular segment for a conversion process that is being operated, the program will flow on a “Y” path to a first subjob decision block **1708** that determines if the page is associated with the first subjob. If so, the program flows along a “Y” path to a function block **1710** to process the operators, similar to block **1406** in FIG. **14**. If it is not Subjob A, the program flows to a decision block **1712** to determine if the page is associated with Subjob B. If so, the program will flow to a function block **1714** to process the operators therein. If it is determined not to be Subjob A and not Subjob B, then it must be Subjob C and the program then flows to a function block **1716** to process the operators therein. The program will flow to a decision block **1718** to determine if all operators in a particular page have been processed. Until they have been processed, the program will loop back around to the input of decision block **1708**. Once processed, the program will flow to a function block **1720** to render the page and then to a decision block **1722** to determine if it is the last page in the segment. If not, the program will loop back to the input of function block **1706**. At the end of the last page in the segment, the program will flow to a block **1724** to exit the program.

At the decision block **1706**, when it is determined that the pages is not within the segment, the program will proceed as described hereinabove with respect to FIG. **14**, i.e., it will skip the graphics operators and flow directly to the input of decision block **1722**.

Although the preferred embodiment has been described in detail, it should be understood that various changes, substitutions and alterations can be made therein without departing from the spirit and scope of the invention as defined by the appended claims.

What is claimed is:

**1.** A method for parallel conversion processing of a print job in a print system having a plurality of RIP engines, comprising the steps of:

defining the print job for RIPing of select portions of the print job in parallel;

partitioning the print job into select portions according to defined boundaries for processing in parallel;

generating a substitute RIP instruction for each select portion of the print job; and

processing the RIP requirements of each select portion in an assigned one of the plurality of RIP engines according to the substitute RIP instruction.

**2.** The method of claim **1**, wherein the step of defining the print job comprises the steps of:

spooling the print job file into storage;

updating document information in a job control file associated with the print job file; and

processing document information obtained from the job control file.

**3.** The method of claim **2**, wherein the step of updating document information includes the steps of:

making assumptions about a document parameter to enable an estimating engine to estimate the value of the document parameter; and

estimating the value of the document parameter.

**4.** The method of claim **2**, wherein the step of processing document information comprises the steps of:

engaging a language processor for extracting selected document information from the contents of the job control file;

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reading the contents of the job control file; and  
defining boundaries for partitioning the print job into select portions.

**5.** The method of claim **4**, wherein the language processor includes a job estimator for estimating the total number of pages in the print job.

**6.** The method of claim **1**, wherein the step of partitioning the print job comprises the steps of:

determining whether single or multiple RIPs are to be performed;

partitioning the job into one or more select portions to be RIPed if a multiple RIP is to be performed, wherein at least a portion of less than all of the print job is selected for processing; and

defining the RIP requirements for each select portion of the print job.

**7.** The method of claim **6**, wherein the step of determining includes the step of:

testing the print job control file for satisfaction of a boundary condition.

**8.** The method of claim **7**, wherein the step of defining the RIP requirements comprises the steps of:

accessing the document information and RIP requirements for the entire print job;

determining the range of each select portion to be separately RIPed; and

identifying the RIP requirements for each select portion with the determined range of each select portion to be RIPed.

**9.** The method of claim **1**, wherein the step of generating a substitute RIP instruction comprises the steps of:

configuring the substitute RIP instruction to perform RIP only upon an identified select portion of the print job;

resetting the predefined operator instructions associated with the print job file as input to the print system;

appending the substitute RIP instruction associated with each identified select portion of the print job to the print job; and

selecting a RIP engine to perform RIP upon each identified select portion of the print job.

**10.** The method of claim **1**, wherein the step of processing the RIP requirements of each select portion comprises the steps of:

distributing the print job in parallel replication, each print job replication having appended thereto a particular substitute RIP instruction associated therewith, to each select one of a plurality of RIP engines associated with the identified select portion of the print job to be RIPed in parallel;

performing, in each select one of the plurality of RIP engines, the RIP of the print job distributed to each select one of the plurality of RIP engines; and

rendering each select portion of the print job for which RIP according to the appended substitute RIP instruction was performed.

**11.** The method of claim **10**, wherein the step of performing the RIP of the print job comprises the steps of:

reading, in each select one of the plurality of RIP engines, the appended substitute RIP instruction to identify the select portion for which RIP is to be performed and to identify the remaining portion for which a modified RIP is to be performed;

RIPing, in each RIP engine selected to RIP the select portion of the print job, of the select portion of the print job according to the appended substitute RIP instruction; and

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performing the modified RIP upon the remaining portion of the print job.

12. The method of claim 10, wherein the step of rendering comprises the steps of:

5 sending each select portion of the print job, for which RIP according to the substitute RIP instruction was performed, to a selected print engine;

printing each select portion of the print job; and merging the printed outputs.

13. The method of claim 10, wherein the step of rendering comprises the steps of:

determining whether the select portion is to be displayed; sending the select portion of the print job, for which RIP

15 according to the substitute instruction was performed, to a selected display; and

displaying the select portion of the print job.

14. A method for processing a PDL document file distributable in multiple to a plurality of process engines coupled in parallel comprising the steps of:

20 determining allocation parameters for defining a select and a remaining portion of each multiple of the document file to be distributed to a select one of the plurality of process engines;

25 generating instructions, for operating respectively according to a first process and a second process on the select and remaining portions of each document file, for execution by each select one of the plurality of process engines; and

30 appending the instructions, generated for each multiple of the document file, to the associated document file for execution by the select ones of the plurality of process engines upon distribution of the respective document files thereto.

15. The method of claim 14, further comprising the step of:

35 executing, in each process engine receiving distribution of a multiple of a document file, the first process upon the select portion of the document file and the second process upon the remaining portion of the document file.

16. The method of claim 15, wherein the first process comprises the step of:

40 executing conversion processing upon the defined select portion of each multiple of the document file in each process engine receiving a multiple of the document file.

17. The method of claim 16, wherein the step of executing conversion processing comprises the step of:

45 performing conversion processing upon the defined select portion.

18. The method of claim 16, wherein the step of executing conversion processing comprises the step of:

50 performing conversion of the defined select portion from a first page format structure to a second page format structure.

19. The method of claim 15, wherein the first process comprises the step of:

55 executing conversion processing upon the defined select portion of each multiple of the document file in each process engine receiving a multiple of the document file.

20. The method of claim 15, wherein the second process comprises the step of:

60 executing modified conversion processing upon the remaining portion of each multiple of the document file

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in each process engine receiving a multiple of the document file wherein some or all of the remaining portion is bypassed during the modified conversion processing.

21. The method of claim 20, wherein the step of executing modified conversion processing comprises the step of:

performing modified conversion processing upon the remaining portion wherein some or all of the remaining portion is bypassed during the modified conversion processing.

22. The method of claim 20, wherein the step of executing modified conversion processing comprises the step of:

performing modified conversion of the remaining portion from a first page format structure to a second page format structure wherein some or all of the remaining portion is bypassed during the modified conversion.

23. The method of claim 15, wherein the second process comprises the step of:

20 executing modified conversion processing upon the remaining portion of each multiple of the document file in each process engine receiving a multiple of the document file wherein some or all of the remaining portion is bypassed during the modified conversion processing.

24. The method of claim 14, wherein the process engine comprises:

a conversion processor.

25. The method of claim 14, wherein the step of determining allocation parameters comprises the steps of:

spooling the document file to an input processor;

engaging a language processor for developing the allocation parameters; and

35 defining boundaries of the select portions of the document file for distribution.

26. The method of claim 25, wherein the step of engaging a language processor comprises the steps of:

40 monitoring the document file being spooled for extracting page header information; and

developing the allocation parameters therefrom.

27. The method of claim 26, wherein the step of developing the allocation parameters includes the steps of:

45 estimating the number of pages in a document file; and

allocating a range of the number of pages to the select portion for processing by a select one of the plurality of process engines.

28. The method of claim 14, wherein the step of generating instructions comprises the steps of:

50 determining that the first process, a conversion step, is to be performed on the select portion;

determining that the second process, a modified conversion step, is to be performed upon the remaining portion;

55 resetting the original instruction operators associated with the input document file; and

accessing the instruction operators associated with the first and second processes for appending them to the associated portions of the document file.

29. The method of claim 14, wherein the step of appending the instructions comprises the step of:

60 substituting the instruction operators associated with the first and second processes respectively for operating upon the select and remaining portions of the document file.

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30. The method of claim 14, wherein the process engine comprises:

a processor for performing document file conversion.

31. The method of claim 14, wherein the process engine comprises:

a virtual processor for performing document file conversion.

32. A method for converting a primary document from a first page delineated format to a secondary document in a second page delineated format, comprising the steps of:

accessing the first document; and

converting only select pages of the primary document to the second page delineated format wherein the converted pages comprise the secondary document and wherein the secondary document has less pages than the primary document.

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33. The method of claim 32, wherein the step of converting requires access to a larger portion of the primary document than that associated with the select pages.

34. The method of claim 31, wherein the primary document comprises a page independent format and the second page delineated format comprises a page dependent format.

35. The method of claim 31, wherein the first and second delineated formats are the same.

36. A method for converting a primary document from a first page delineated format to a secondary document in a second page delineated format, comprising the steps of:

accessing the primary document; and

converting select pages of the primary document from the first page delineated format to the second page delineated format, the step of converting being a function of the parameters of the select pages.

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